SCIENCE

6 May 1960
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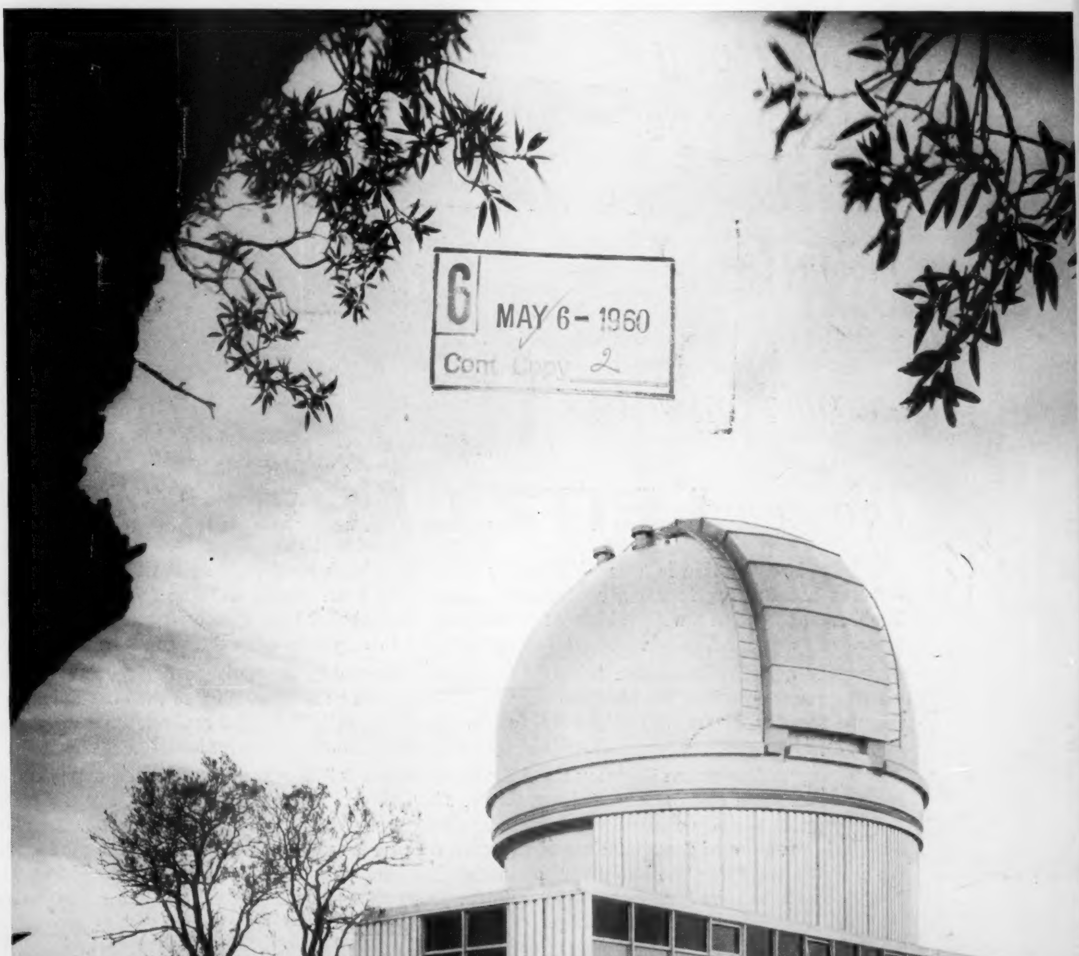

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EXAMPLE

Identification of Intermediate Substrate Free-Radicals formed during Peroxidatic Oxidations

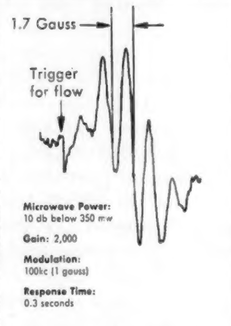

Fig. A. Semiquinone

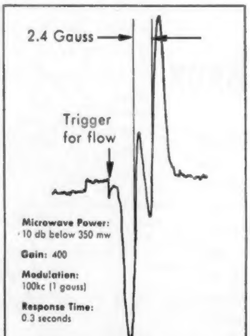

Fig. B. Ascorbate Intermediate

A considerable amount of work utilizing the technique of electron paramagnetic resonance (EPR) to detect free-radical production in typical enzyme-substrate oxidation-reduction reactions has been reported. For the most part the EPR signals that have been observed in the system have been associated with the enzyme itself, or with a change in valance state (i. e., to a paramagnetic state) of the metal in the metalloflavoproteins. In no case has evidence been presented to associate the free radical signal with the substrate undergoing oxidation or reduction. The EPR technique is valuable not only for detecting free radicals but can also be used to identify the type of free radicals in a system and provides a direct measure of their concentration, since the total intensity of the spectral lines is directly proportional to the concentration of free radical intermediates present. With the improved sensitivity and larger sample volumes obtainable, it is now possible to re-investigate free radical production in these biological systems.
In the research described (see illustrations), EPR has been used to detect, identify, and follow the kinetics of free radical formation and decay in the oxidation of ascorbic acid by an enzyme in H_2O_2 solution. These observations were made with a Varian 100 kc EPR Spectrometer, utilizing a flat sample cuvette attached to a flow system for kinetic measurements. The enzyme was recrystallized Japanese turnip peroxidase.*

Figure A illustrates the free-radical spectrum obtained from a mixture of enzyme ($8x10^{-8}$M) and a solution of hydroquinone (10^{-2}M), H_2O_2 (10^{-2}M) and acetate buffer (pH 4.8). The measured concentration of free radicals from this enzyme reaction was $1.3x10^{-6}$M in the steady state.

Figure B shows the intermediate formed during the peroxidatic oxidation of ascorbic acid in a steady state reaction. The concentration of free radicals resulting from the reaction of ascorbic acid (10^{-2}M), H_2O_2 (10^{-2}M), and peroxidase ($1.6x10^{-7}$M) at pH = 4.8, was $7.2x10^{-6}$M.

There is no doubt that the free radicals generated during the peroxidatic oxidations of hydroquinone and ascorbic acid are derived from the substrates.** The enzymic generation of free radicals from substrates, which have been observed in this investigation by electron paramagnetic resonance spectroscopy, suggests that aerobic life may have an inherent genetic instability due to mutations which such free radicals could produce. This interesting possibility seems to merit further investigation.

**Samples courtesy of I. Yamazaki and H. S. Mason, Department of Biochemistry, University of Oregon Medical School, Portland, Oregon, U. S. A.*

***See: Yamazaki, Mason and Piette; Biochem. and Biophys. Comm; Vol. 1, No. 6, pp. 336-337.*

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6 May 1960, Volume 131, Number 3410

SCIENCE

Cover Building for 36-inch reflector at Kitt Peak National Observatory. Pattern suggestive of Indian influence is used on screen shielding parking lot and entrance to the building. See page 1341. [Manley]

6 May 1960, Volume 131, Number 3410

SCIENCE

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Claim to Fame

So far as we know, no team of linguists and sociologists has as yet made a joint attack on the problems posed by the evolution and distribution of the alphabetical abbreviations for institutional names. Unquestionably the condensation of titles saves effort in speaking and cost in printing, but other factors doubtless serve to increase the currency of the short forms. An element of gamesmanship surely plays some part. No one is going to refer to the Atomic Energy Commission by its full title among his scientific peers for fear they might think him unfamiliar with "AEC." But no simple rule prevails for the formation of such abbreviations. The National Bureau of Standards is invariably referred to in conversation as "the NBS," but the National Gallery of Art is never called "the NGA."

Perhaps a little classification of abbreviations will be useful. The classic type is formed from the initial letters of all or almost all of the words that make up the institutional title, but the abbreviation so formed does not form a word. The letters are pronounced one by one. Familiar examples are FBI, CIA, and NAS–NRC.

The other common, though more recent, type of abbreviation is, like the classic type, formed from the initial letters of some or all of the words in the title, but the title has been so arranged that these initial letters can be pronounced in syllables, as words. To one not familiar with them, these words give a strange, even a barbaric, flavor to the language. Among them are UNESCO, NATO, ICSU (pronounced "ik-sue" and translated as the International Council of Scientific Unions), and ARPA–IDA (pronounced as spelled and translated as Advanced Research Projects Agency–Institute for Defense Analysis).

Some others fail to fit into either pattern. Thus, MIT (for Massachusetts Institute of Technology), DOD (for Department of Defense), and FID (for Fédération Internationale de Documentation) could be, but happily never are, treated as words. Another type of shortened title is made up of some of the initial letters combined with an abbreviation of a word. Among these hybrid types are *Aslib* (pronounced "ah-slib" and standing for the Association of Scientific Libraries) and AMSOC, for the American Miscellaneous Society.

The American Association for the Advancement of Science is abbreviated as the AAAS. To pronounce this form letter by letter would be tedious and would convey an impression of indecision: "eh, eh, eh, ess." This is avoided in two ways: physicists and mathematicians call it "the ā-cube-ess" (A^3S); all others run it smoothly off their tongues as "the triple-ā-ess."

To look at it from another angle, widespread recognition of an abbreviated title is an indication of fame and status. Recently, a young institution has moved into the elite group of organizations whose shortened titles have national currency. We congratulate the NSF, the National Science Foundation, on the occasion of its tenth birthday, 10 May 1960, for achieving such fame at so tender an age and, what is more important, for having developed in such a way that it has earned the respect of the nation's scientists. May the NSF continue its good work in support of research, education, and communication in the sciences for ten to the *n*th (10^n) years.—G.DuS.

6 May 1960, Volume 131, Number 3410

SCIENCE

National Science Foundation: A Ten-Year Résumé

Its obligations in support of research and training and in evaluating national science policy have multiplied.

Alan T. Waterman

The National Science Foundation's first 6 years were analyzed with scholarly thoroughness by Dael Wolfle in *Science* in 1957 (*1*). I shall not attempt to review the factual data concerning the organization and operations of the foundation that are given in detail in his article. I shall take up the narrative essentially where he left it, at the beginning of fiscal year 1958. Whatever I have to say concerning the earlier period will be from the special point of view of one who has been intimately involved in shaping the foundation's policies and operations during its formative years.

As visualized by Vannevar Bush in *Science, the Endless Frontier*, and as defined by Congress in the National Science Foundation Act of 1950, the foundation has two distinct sets of functions; one relates to the support of research and education through grants, fellowships, and other means, and the second involves the development of national science policy and the evaluation and correlation of the research activities of the federal government, as well as the correlation of its own program with those of other agencies, both public and private. There is a degree of difficulty in reconciling these two functions, because in planning and operating a research-support program the foundation becomes to some extent an interested party with respect to the policy prescribed. Congress obviated this situation somewhat by denying the foundation authority to perform research or to establish its own research laboratories.

In the first or operational category, planning and execution have been reasonably straightforward. Early in its history the foundation adopted the grant as being the most flexible and effective means of support for basic scientific research. In the field of education it was decided that the graduate fellowship was the device that would produce the most immediate results in terms of trained manpower. Within the budgetary limits imposed by Congress, the foundation immediately launched a graduate fellowship program and a research-support program which embraced all the natural sciences and, later, selected areas in the social sciences.

The policy-making functions, as well as the evaluation functions prescribed in the act were less susceptible of immediate and specific action, for reasons Wolfle pointed out.

In *Science, the Endless Frontier*, Bush had visualized that a National Research Foundation would be the principal, if not, indeed, the sole, point of reference for federal support of basic or uncommitted research in the postwar period. In view of the brilliant success of the wartime Office of Scientific Research and Development, this was a logical plan for taking care of the nation's research needs in science. So urgent were these needs, however, particularly in the mathematics, science, and engineering departments of universities, and so urgent was the nation's need for scientific research that the provision of federal support could not await the outcome of the 5-year congressional debate over legislation to establish the National Science Foundation.

The foresight of Secretary of the Navy Forrestal in establishing the Office of Research and Inventions—which in 1946 became the statutory Office of Naval Research—made it possible for the Navy to provide critically needed support for basic research at universities. This program was followed in short order by the programs of the Federal Security Agency, notably those of the U.S. Public Health Service and the National Institutes of Health, and those of the Atomic Energy Commission. When the National Science Foundation began to operate in 1951, initial policy had been formulated and active support of science was under way, and as a result there was pressing demand for (i) impartial support of basic research and training unrelated to such practical missions as defense and health and (ii) supervision, coordination, and policy determination among the growing and splintered research-support programs of the federal government.

Equipped with a broad charter, a limited but growing staff, and an operating budget of $3.5 million, the new foundation found itself under pressure almost immediately to start performing policy-making and evaluation functions. In addition, of course, it was expected to launch, as early as possible, programs in support of basic research and education in the sciences.

The author is director of the National Science Foundation, Washington, D.C.

Development of National Science Policy

In this situation, the National Science Board and the director sought to define more specifically the role of the National Science Foundation in relation to other agencies. After extensive conferences between National Science Foundation staff members and the Bureau of the Budget and other agencies, the foundation made a series of recommendations which were incorporated in Executive Order 10521 of 17 March 1954 (*2*). The order states that the foundation "shall . . . recommend to the President policies for the promotion and support of basic research and education in the sciences, including policies with respect to furnishing guidance toward defining the responsibilities of the Federal Government in the conduct and support of basic scientific research."

The order further directs that the foundation shall be increasingly responsible for the support of general-purpose basic research but recognizes also the importance and desirability of having other agencies conduct their special basic research in fields closely related to their missions. The foundation is not expected to have responsibility for the applied research and development program of other agencies; each agency is accountable for the scope and quality of its development efforts.

The Executive Order of 13 March 1959 [section 6(*b*)] further clarified the foundation's role as applying only to *basic* research. Within this more specialized framework, the foundation has been steadily formulating national science policy in the course of day-to-day operations, frequently on the basis of agreement and understanding with other agencies. Those who insist that policy must be handed down "ready made" in the form of a proclamation or edict do not understand the nature of policy in the realm of science. To be workable, policy must evolve on the basis of experience; further, it must take fully into account the fundamental principles essential to the effective performance of research in science.

In carrying out its obligations regarding the development of national science policy, the foundation started from the premise that, in its broadest sense, national policy for science is a matter primarily to be determined by the scientists themselves. The scientists of the country are unquestionably the ones most capable of deciding what is best for progress in science, in the true meaning of the word. Policy in this sense should not be "master-minded" by the federal government or any single agency.

The foundation has advocated, and has itself adopted, the fairly general federal policy of providing support to basic research after consultation with leading scientists in their respective fields. This would appear to be the most direct way in which progress in science in the country can be determined by the scientists themselves. It is the method that is favored by the majority of working research scientists. In carrying out this policy, a given federal agency interjects its own interests and priorities.

In further development of science policy, the foundation's approach has been to examine particular issues and to develop recommendations through a variety of techniques and devices, as follows.

1) The establishment of a special committee, followed by the issuance of a report. The principal example here is the foundation's study, through two different committees, of the problems of government-university relationships. This study availed itself of the assistance of outside individuals and groups, the foundation staff, members of the National Science Board, and representatives of other government agencies. Another example is the work of the foundation's Special Commission on Rubber Research, which made recommendations on the role of the government with respect to basic research in this field that were approved by both the President and Congress.

2) Preparation of special reports on particular subjects—for example, the foundation report on "Basic Research—A National Resource" (1957).

3) The use of experimental programs by the foundation as a means of acquiring information and experience to provide a basis for policy recommendations. The various experimental programs in science education, such as the Physical Sciences Study Committee, are examples of this approach.

4) Conduct of studies and issuance of reports upon request of the Executive Office of the President. The foundation's report on the role of the federal government in international science, its report on federal support of research facilities, and its recommendations regarding payment of indirect costs were prepared at the request of the Executive Office of the President.

5) Sponsorship of legislation on particular problems. An outstanding example is the successful foundation sponsorship of legislation to extend to all agencies of the government the authority to make grants for the support of basic research and the authority to vest title to research equipment with educational institutions. In this and other similar administrative policy matters the Interdepartmental Committee for Scientific Research and Development was helpful.

In 1959 the foundation compiled a list of some 50 science-policy items of a government-wide, national character that it has recommended or stressed. Drawn from a variety of public statements and published reports, these include: (i) the need for increased support of basic research; (ii) the need for increased opportunities and funds for basic research at federal laboratories; (iii) greater stability and continuity in federal support of basic research at universities; (iv) the need for diversity of sources of support of basic research in the federal government and need for basic research in support of development; (v) avoidance, to the extent possible, of large classified developmental undertakings by the government at colleges and universities; (vi) payment of full indirect costs of federally sponsored research at universities and colleges; (vii) reasons for questioning the advisability of establishing a Department of Science and Technology; (viii) policy concerning loyalty of investigators on basic research grants.

Studies in support of policy. As background data for its own research programs and for policy formulation concerning the role of the federal government in the support of science, the foundation established a continuing series of studies of the nature and extent of the national effort in research and development. Comprehensive surveys are made of the research and development effort of colleges and universities and other nonprofit institutions and of industry. Initiated for the year 1953–54, these surveys measure research and development in terms of (i) dollars expended, (ii) professional personnel employed, and (iii) apportionment of effort between basic research, applied research, and development. With 1953–54 as the base year, future surveys will afford data to indicate trends and for other analytical purposes. These surveys are in addition to the foundation's analyses of the support of research and development by federal agencies, published annually in *Federal*

Funds for Science. The whole series carries out the executive order "to make comprehensive studies and recommendations regarding the Nation's research effort and its resources for scientific activities. . . ."

Questions are sometimes raised concerning the value of attempting a breakdown of research and development activities in this way. The objection is made that in the pursuit of specific objectives—as, for example, by technical industries—the planning and execution involve all three categories in close coordination. Furthermore, individuals are often found who can participate effectively in all three areas. The latter are in much demand as project leaders and administrators of government and industrial research and development.

The foundation believes that study of these categories is warranted for a number of reasons. Leaders in science and technology feel generally that more basic research could profitably be performed by government and by industrial laboratories. Similarly, scientists and educators have questioned the extent to which universities should engage in applied research and development, outside of certain areas such as engineering, medicine, and agriculture. Furthermore, it is desirable in any intelligent planning of science and technology to identify students with special aptitudes and to insure that such aptitudes are properly taken into account in the individuals' career plans. But by far the most important consideration is the need to emphasize the importance of basic research itself.

Under the increasing pressure to undertake and perfect critical developments in order to attain national or economic objectives, the emphasis is certain to be on the applications of science, particularly in view of budgetary and manpower limitations. Therefore, unless a determined effort is made to support basic research, developments will inevitably be undertaken prematurely, career incentives will gravitate strongly toward applied science, and opportunities for making major scientific discoveries will be lost. Unfortunately, pressures to emphasize new developments, without corresponding emphasis upon pure science—that is, basic research—tend to degrade the quality of the nation's technology in the long run, rather than to improve it.

Under these circumstances the need for study and analysis of the facts is obvious.

Evaluation of Research Programs

A problem that matches in complexity the policy function is that of evaluation. The National Science Foundation Act makes the foundation responsible for the evaluation of scientific research programs undertaken by agencies of the federal government and for a correlation of the foundation's scientific research programs with those undertaken by individuals and by public and private research groups. The foundation has consistently pointed out, however, that it is unrealistic to expect one federal agency to render judgment on the over-all performance of another agency or department.

The foundation has chosen, instead, to approach the problem through close liaison and exchange of information with other science agencies. The idea is to gain a comprehensive idea of the federal programs and over-all support of *fields* of science such as physics, mathematics, and biology. The adequacy of federal support in each field may thus be considered. This procedure is implemented by the general technique of basing research support upon selection among applications or proposals received. By these measures the foundation has endeavored to identify areas that are receiving inadequate support or which require attention for other reasons.

It was discovered, for example, that systematic biology and, more recently, inorganic chemistry were being inadequately supported. Word that the foundation would be receptive to proposals in the fields of systematic biology has resulted in the rescue of this field from comparative neglect, and in all likelihood the same results will obtain with respect to inorganic chemistry.

Another example will serve to illustrate this point. A few years after the close of World War II, both the Office of Naval Research and the Atomic Energy Commission were providing considerable support to research on low-temperature physics. When the time came that neither agency felt justified in continuing its support at the existing level, the foundation agreed to take over the major support of research in low-temperature physics.

Critical Areas of Science

A related matter that will call for increasing attention on the part of the federal government and other sources of support for research and development is the question of special emphasis on particular areas of science. The issue frequently arises in determining critical areas or, from another point of view, in identifying "gaps." In all developmental work, and in the search for areas of application, the importance of priorities of time and effort is an accepted fact. In pure science, the word *priorities* is inappropriate and misleading. No field of science can properly be said to have priority over other fields, *as science*. However, at a given time, in a particular field of science, it is common to find special lines of inquiry that for the moment are making rapid progress or other lines of inquiry that are meeting difficulty. These considerations can be, and indeed are, taken into account both by individual research scientists and by research agencies concerned in research support. Thus, at any time there may develop what might be termed "critical areas" that it is currently important to foster. If the urgency is great, a conference on the subject may be in order, or possibly a thorough study undertaken to ascertain what special facilities, equipment, or training may be needed to encourage progress in the field. These are well-known techniques, in common use. It seems evident that, in years to come, increasing attention will be required along these lines, since there will undoubtedly be a tendency for groups of scientists to present for support plans and programs that represent their collective thinking. Agencies that provide support will then have to evaluate the needs of different groups in the light of current available information and knowledge—and funds. However, the existence of special patterns for critical areas should not be allowed to alter the view that support of research, across all fields of science, should be carried on on a continuing basis.

New Mechanisms and Agencies

The tasks of policy-making, evaluation, and coordination have been further clarified by the establishment of new mechanisms and agencies that did not exist at the time Dael Wolfle's article appeared in 1957.

In the fall of 1958, after the launching of the first Russian sputnik, President Eisenhower called for redoubled efforts in science and technology, and

steps were taken to strengthen the government's leadership with respect both to science and technology and to education in the sciences. The position of Special Assistant to the President for Science and Technology was created. The President's Science Advisory Committee was expanded and strengthened and undertook at once a series of studies covering significant aspects of the government's relationships to science, technology, and education.

The science activities of the Department of State, which had been allowed to lapse, were revived. A Science Adviser to the Secretary of State was appointed, and science attachés were again placed in key diplomatic posts.

Finally, in response to recommendations of his Science Advisory Committee, the President signed an executive order, in March 1959, establishing the Federal Council for Science and Technology, to promote closer cooperation among federal agencies in planning their research and development programs and to recommend ways in which the federal government can assist in advancing and strengthening the nation's scientific efforts as a whole. Represented on the council are the Departments of Defense, Interior, Agriculture, Commerce, and Health, Education and Welfare; the National Science Foundation; the National Aeronautics and Space Administration; and the Atomic Energy Commission. Representatives of the Secretary of State and the Director of the Bureau of the Budget attend as observers.

Thus, at the present time we have the following pattern: the National Science Foundation, with its National Science Board, has the primary responsibility for dealing with policy concerning federal support of basic research throughout the country. The Federal Council for Science and Technology deliberates on matters of policy and program coordination and future planning among federal agencies and makes recommendations to the President. The President's Science Advisory Committee, comprising nongovernment scientists and engineers, considers important scientific and technical matters in relation to government policy, with special reference to national security. The Special Assistant to the President for Science and Technology is available to the President at all times for advice or counsel on a wide range of scientific and technical matters.

Rate of Over-All Growth

During the first phase of its operations the National Science Foundation was occupied with its own structure and staffing, with the definition of its functions and responsibilities, and with providing a firm foundation for its two major programs: research support and education in the sciences. From the beginning it has also been steadily involved in policy determination both for itself and in terms of federal support of science.

During its first 5 years the foundation's appropriation climbed slowly from an initial \$3.5 million for the first year to \$16 million for the fifth year, fiscal year 1956. In the second half of the decade there has been a marked upswing in appropriations, from \$40 million in fiscal year 1957 to the current level of \$152.773 million (see Table 1).

In connection with the growth of appropriations, note should be taken of the perspicacity of Congress in endeavoring to strengthen the programs in education in the sciences at least two years before launching of the Russian sputnik. In the summer of 1955 the foundation published a National

Table 1. Total appropriations and obligations of the National Science Foundation for fiscal years 1952–60 (to the nearest thousand dollars).

Field	1952	1953	1954	1955	1956	1957	1958	1959	1960
					Appropriations (thousands)				
	3,500	4,750	8,000	12,250	16,000	40,000	49,750	136,000*	154,773*
					Obligations (thousands) †				
Development of graduate laboratories									2,000
Biological and medical sciences									
Basic research	736	831	1,966	3,612	4,793	7,361	8,540	19,805	24,405
Research facilities					125	885	987	3,270	2,000
Math., phys., and engineering sciences									
Basic research	311	983	2,033	4,244	4,700	7,619	9,536	22,985	33,489
Research facilities									
University computing facilities							200	1,500	1,500
Major engineering-physics facilities						500	450	2,000	2,000
Oceanographic research vessel									3,000
Atmospheric sciences									500
National Radioastronomy Observatory				104	147	3,431	1,587	4,419	922
Kitt Peak National Observatory				50	250	545	3,100	4,391	3,749
Other							67‡		
Social sciences									
Basic research						289	554	853	1,925
Special international programs									
Antarctic research							446	2,306	7,248
Office of special studies									
Surveys and report	130	42	310	349	97	47	222	230	367
Office of Scientific Information Service									
Distribution of scientific information	87	119	174	303	395	905	1,938	3,848	5,392
Scientific personnel and education									
Training of scientific manpower	1,644	1,477	2,120	2,297	3,718	14,698	19,414	62,070	64,477
Operating costs	531	972	1,351	1,528	1,764	2,351	2,933	5,261	6,188
Total obligations	3,766	4,424	7,954	12,486	15,989	38,630	49,973	132,940	159,162

* Includes a \$2 million appropriation transfer from AEC for nuclear research reactors. † 1960 obligations estimated. ‡ Feasibility study for astrograph.

Research Council study, *Soviet Professional Manpower*, which drew sobering comparisons between the rates at which the United States and the Soviet Union were training scientists and technical manpower. Largely as a result of these findings Congress markedly increased the foundation's funds for education in the sciences. The total appropriation for fiscal year 1957, $40 million, was more than double that for the preceding year.

During the 10-year period since it was established, the foundation has successively outgrown three locations in Washington: a private residence (901 16th Street, NW), a former school (2144 California Street), and the old Cosmos Club at H Street and Madison Place. Its present headquarters, 1951 Constitution Avenue, became overcrowded almost as soon as the foundation moved in. Additional space has recently been acquired at 528 23rd Street, NW, and it is expected that further expansion will be necessary.

Support of Research Facilities

With increased appropriations, the foundation has been able to expand its activities in areas that have long needed attention and for which it had previously lacked funds. One of the first areas to claim its attention was the need for basic research facilities. In response to a request from the Bureau of the Budget in 1956, the foundation undertook a study of the subject and published its findings in a report of June 1957, *Federal Support of Physical Facilities and Major Equipment for the Conduct of Scientific Research*. The study pointed out that basic research today increasingly requires the use of large, complex, and expensive research tools. Although government expenditures for research facilities since World War II have run into the hundreds of millions of dollars, for the most part these have been committed to practical research and hence have been available only to a small degree for purposes of basic research.

Traditionally, universities and other private research organizations have provided needed research tools from their own funds or from funds available from state or local sources. Now, however, the need for such major equipment as nuclear reactors, high-energy particle accelerators, high-speed computers, and radio and optical telescopes is too great to be met from such local resources or even from the combined resources of several institutions. The report concluded that if American science were to advance at a satisfactory rate, federal support of needed facilities would have to be provided.

Table 2. Comparison of research proposals considered and supported in the biological and medical sciences; mathematical, physical, and engineering sciences; and social sciences (weather modification and antarctic research not included).

Fiscal year	Proposals for research grants ($)		Percentage of support	Av. amount of grants awarded ($)	Av. life of grant (yr)
	Considered	Supported			
1952	13,300,000	1,074,000	8.0	11,156	1.9
1953	17,478,000	1,813,000	10.4	10,540	1.9
1954	27,159,000	3,999,000	14.7	11,100	2.5
1955	38,046,000	7,855,000	20.6	13,350	2.7
1956	54,133,000	9,493,000	17.5	13,641	2.1
1957	78,318,000	14,979,000	19.1	14,934	2.1
1958	126,500,000	18,630,000	14.7	17,000	2.1
1959	179,671,000	43,644,000	24.3	25,900	2.3
1960	221,118,000	57,819,000	26.1	30,500	2.3

In embarking upon a program in support of facilities, the foundation has recognized that each case must be judged on its individual merits. It is difficult to establish criteria that would be applicable in all cases. Factors taken into consideration include the urgency of the need, the national significance of the development, the availability of adequate personnel, and the degree and character of local backing. Recipient institutions are encouraged to participate financially to the extent possible. The foundation has also recognized that in some situations the federal government must continue to supply funds for operation and maintenance, in addition to funds for construction.

The foundation is presently supporting two major facilities in astronomy, the National Radio Astronomy Observatory at Green Bank, West Virginia, and the Kitt Peak National Observatory at Tucson, Arizona. Both of these projects were undertaken only after intensive studies by astronomers extending over a period of several years. Determination of the types of facilities and instruments needed was followed in each case by exhaustive search for suitable sites.

Other facilities being supported by the foundation include biological field stations, construction of an oceanographic research vessel, university computing facilities, university nuclear research equipment, and facilities needed to expand research in the atmospheric sciences.

Closely related to the facilities program is the recent Graduate Laboratory Development Program, under which the foundation provides funds on a matching basis for the modernization and equipment of research laboratories. Studies of the situation indicate that the graduate-level research laboratories of the nation's universities are obsolescent to a degree that is detrimental to the national basic research effort. The financial straits in which most of our institutions of higher learning find themselves make it impossible for them to provide modern, well-equipped laboratories entirely out of their own funds.

This program was initiated in a modest way in fiscal year 1960, in the amount of $2 million. The budget for fiscal year 1961 provides for a substantial increase in the support level for this area.

Research Support

The increases in the foundation's appropriation are reflected in the research support program in several ways. First, and most obvious, is the growth in the total number of grants awarded, growth in the percentage of proposals supported, and increases in the amount and duration of the average grant (see Table 2). In fiscal year 1952 the foundation was supporting 8 percent of all proposals received, for a total of $1.074 million. In the current fiscal year, support is provided for 26 percent of the proposals received, for a total value of $57.819 million. In 1953, the average grant was $10,300, for an average period of 1.9 years. In 1960, the average grant was $30,500, for an average period of 2.3 years. These figures indicate that the foundation, with its increased funds, is able to support

individual projects more fully than before and that greater stability in support is being achieved through a gradual increase in the life of the average grant. It should be noted, however, that if the funds available for the support of research have risen, so too has the demand. To date, the foundation has not been able to support more than one-third of all the meritorious proposals received.

Up to the present, support for basic research has been divided approximately equally between the mathematical, physical, and engineering sciences and the biological and medical sciences, but beginning with 1960, the balance is weighted somewhat on the side of the physical sciences.

Support for basic research in the social sciences, initially divided between the two natural science divisions, began at a very modest, experimental level below $50,000. In 1958, the program was given the status of a separate program, and support was at the level of $725,000. At the end of 1958, the National Science Board approved the establishment of an Office of Social Sciences, and in the current year support has risen to $1.6 million. Only those projects are supported that are susceptible to scientific approach and that are truly fundamental in character.

Thus, the foundation is prepared to support research of this type in such fields as archeology, economics, philosophy of science, linguistics, social anthropology, demography, history of science, and social psychology.

Methods of research support. The general pattern under which federal agencies support research at institutions outside the federal government, particularly universities, originated with the Office of Scientific Research and Development during the war and provided the means whereby the federal government could benefit from important research carried on outside its own laboratories. The principle was developed and expanded by the Office of Naval Research and the National Institutes of Health after the war and adopted by other agencies, such as the Army, Air Force, and Atomic Energy Commission.

Briefly, the method is this: The government encourages or invites research proposals from individuals or groups of scientists, submitted through their institutions. With the help of individual reviewers in the field involved and of advisory panels appointed by the agency for this purpose, the federal agency selects for support those that are judged to have the greatest scientific merit. The foundation also has statutory divisional committees for over-all review of programs in the three major areas of life sciences, physical sciences, and scientific personnel and education, and a recently appointed committee to operate in similar fashion for the social sciences.

Incidentally, the foundation's efficiency in acting upon grants has been considerably enhanced by the congressional action last year in amending the National Science Foundation Act to permit the Board to delegate authority to the director and its executive committee to approve grants and contracts in certain situations. The delegation of authority has since been implemented by Board action.

The so-called "project method" of research support has a number of advantages. Properly interpreted, the plan is flexible and may be applied to narrowly defined problems in science or to broad areas. It enables the government to move in freely with the support needed for promising and significant undertakings of current interest. It provides for a national program in the sciences, utilizes the advice of the scientists in each field, and is based upon the significance and merit of the research proposed and the competence of the investigators. Since each grant and contract requires the official indorsement of the investigator's institution, the plan has evolved with the concurrence of the nation's universities and has had a most important indirect effect in helping to strengthen such institutions. In fact, such aid has often been of critical importance, particularly for the smaller schools.

The chief drawbacks of this method of research support are its failure thus far to provide full indirect costs and the difficulties it creates in departmental administration. It has also been criticized on the grounds that the reviewing process is slow and that the resulting program is too conservative.

In reply to these criticisms it can only be said that the slowness of the process is the price one pays for operating on the basis of consultation and advice, rather than "master-minding" the system from Washington. Probably it is offset by the great advantage of having the nation's scientific research and development problems widely understood by scientists as they participate in the solution of these problems. If the final results are conservative, it is because groups in general tend to become conservative; but each agency, including the foundation, is responsible for guarding against the conservatism that is apt to result from too much committee advice.

Breadth in project support. With the increased sums available to it for support purposes, the foundation is now able to make more grants of the broader type, often cutting across two or more departments of a university.

Some of the recent grants in this category may be of interest. A $700,000 grant awarded to the University of Pennsylvania will further research being conducted by Britton Chance, director of the Johnson Foundation for Medical Physics, which applies concepts of chemistry and physics to the biological problem of regulation of metabolism within the cell.

A study of the slave-making behavior of ants and its populational consequences is one part of a broad program of "Thesis Research in Population Ecology" being directed by Thomas Park of the Department of Zoology of the University of Chicago. The foundation will contribute support to the extent of $46,700 for the 3-year period.

Scientists at the Massachusetts Institute of Technology will undertake a concerted attack upon the problem of the production and nature of plasmas. Included are studies on gaseous electronics processes, plasma statics, magnetohydrodynamics of compressible and incompressible fluids, ionospheric physics, and some branches of astrophysics. This program, which is under the direction of William P. Allis, is being supported by the foundation with a 3-year grant in the amount of $932,000.

In the field of solid-state physics, Massachusetts Institute of Technology has undertaken a large interdisciplinary program centered about a better understanding of the nature of low-temperature phase transitions. Several departments will participate in this project, which is being supported by the foundation at a level of approximately $400,000 for a 2-year period.

Two major projects in atmospheric physics will operate on similar lines. At Harvard the foundation is supporting a program of atmospheric studies in the general area of physics, applied physics, and applied mathematics. The purpose of the program is to build a

Table 3. Distribution of funds for education in the sciences by major program for the period 1952–60, inclusive.

Major program	Obligations ($1 million)	Percentage of total obligations
Institutes	89.8	51.2
Fellowships	43.3	24.9
Special projects in science education	21.2	12.1
Course content improvement	13.5	7.7
Scientific manpower	3.0	1.7
Other obligations	4.6	2.6
Total obligations (1952–60)	175.4	100.0

small, competent group of workers to engage in aspects of atmospheric study that can be advantageously treated by deductive scientific methods. The ultimate hope is that students trained in the disciplines of physical science will regularly enter the field. The work is under the direction of Richard M. Goody and is being supported by the foundation for a 3-year period at the level of $172,000. At the University of Chicago advantage is being taken of the presence of a group of cloud physicists to establish a program of cloud-physics research dealing with the water resources of clouds. The research covers all the factors believed to be important in precipitation mechanisms. The foundation grant for this program is $383,700 for a 3-year period.

Institutional grants for research. The fact that federal agencies have based their support of research at educational institutions on the principle of grant or contract for a particular research project judged primarily on its scientific merits has led to an increasing lack of flexibility among university science departments in the planning and administration of their own research. As an experimental approach toward a solution of this problem, the foundation is planning to initiate institutional grants to aid institutions in fulfilling their responsibilities for developing and maintaining sound, well-balanced programs of scientific research and research-training activities without precisely specifying what activities are to be undertaken with the funds. The amount of such grants allowable to a particular institution for a given year will be 5 percent of the payments to that institution through basic research grants from the foundation during the preceding year. Such institutional grants would be made on request and without requiring a prior statement regarding the use of the funds by the institution. A report on how the funds were used, however, would be requested. The proportion of research funds distributed by the foundation for research purposes among all types of institutions will not be changed by this plan; the plan is designed to allow each institution to exercise a greater degree of initiative with respect to its needs in scientific activities.

Programs for Education in the Sciences

Between the time of passage of the National Science Foundation Act of 1950 and the end of fiscal year 1960 the foundation's Division of Scientific Personnel and Education will have obligated an estimated $175 million for the support and administration of programs directly related to the improvement of education in the sciences.

These programs have been directed toward the solution of problems in the following four broad categories: (i) support of students of science, mathematics, and engineering, including support of students at graduate levels and above, and support of programs for students at the undergraduate level and below; (ii) aid to teachers of science, mathematics, and engineering, including teachers of science and mathematics at the secondary school level and below and teachers of science, mathematics, and engineering at the college level and above; (iii) the content of science courses; and (iv) public understanding of science.

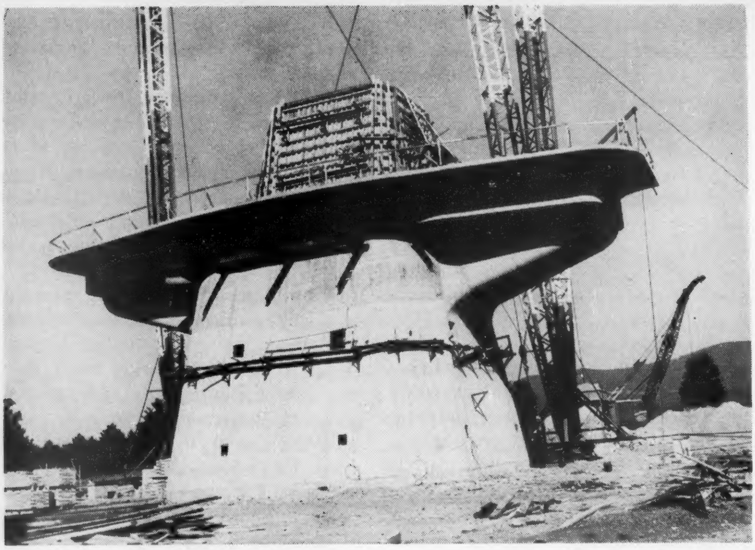
Approximately half of the available funds has been used for the training of secondary school teachers of science and mathematics. The next largest share—about one-fifth of the total—has been used in programs for the training of students at the graduate level and above, primarily in the fellowship programs. About one-fourth of the funds has been used in programs for students at the undergraduate level and below, for course content improvement, and for the training of college teachers.

The primary objective, toward which all the program activities in science education are directed, is to insure an adequate supply of competent scientists and engineers by maintaining a high level of excellence in science education in the face of expanding enrollments, rapid changes in science itself, and the growing need for the products of scientific research and development. The demands upon the educational system have been growing faster than they can be met through the traditional processes. Extraordinary methods, therefore, have had to be developed to assist the educational system in the solution of its problems.

In developing its various programs in education in the sciences, the foundation has been guided by certain broad principles. Its first responsibility has been to work with the ablest people concerned with improving education in the sciences in defining problems to be solved and in seeking solutions to these problems. All decisions with respect both to broad programs and to specific grants are made on the basis of continuous consultation with members of the scientific and educational community. The foundation is concerned with the substance of science, mathematics, and engineering, and its programs are designed to encourage the leading scholars in these fields to take an active part in seeking solutions to problems which bear on the improvement of subject-matter instruction. The foundation has had constantly before it the accepted American principle of local control of education and has observed this principle in its operations. Other federal agencies, universities, private foundations, and industrial organizations are also concerned with education in the sciences and are working toward the same goal. It is our hope and objective that the activities of these several groups may supplement each other in a constructive way.

Let us consider briefly the principal foundation programs under the Division of Scientific Personnel and Education. These include fellowships, institutes, special projects in science education, public understanding of science, course content improvement, and scientific manpower.

The fellowship program. The fellowship program is the oldest support pro-



Foundation for the 140-foot telescope at the National Radio Astronomy Observatory, Green Bank, West Virginia.

gram of the foundation. It was inaugurated in 1952 by the predoctoral and regular postdoctoral programs with a budget of $1.4 million—almost half the foundation's appropriation for that year. As new needs have become apparent, additional programs have been added: in 1956, the senior postdoctoral program; in 1957, the science faculty program; in 1959, the cooperative graduate, teaching assistants, and secondary school teachers programs. By the end of fiscal year 1960, approximately $43 million will have been used for support of graduate students and advanced scholars through these seven fellowship programs. After awards have been made for 1960, an approximate total of 13,000 graduate students and advanced scholars in science, mathematics, and engineering will have received awards, from among about 50,000 applications.

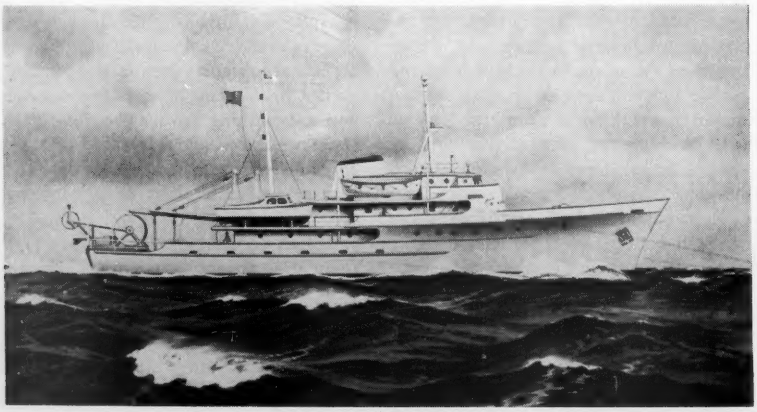
It should be noted, also, that the high standards of selection for foundation fellowships have resulted in wide-spread interest in the applicants, with the result that many of the unsuccessful applicants for foundation fellowships have received awards from other sources. This is particularly true in the case of applicants included in the honorable mention lists published by the foundation each year.

The institutes programs. The institutes programs were inaugurated in 1953 with two experimental projects for college teachers—one in mathematics at the University of Colorado and one in physics at the University of Minnesota. In 1954 the experiment was broadened somewhat to include high school teachers. In 1956 the academic-year institutes program for high school teachers started with two institutes—one at Oklahoma Agricultural and Mechanical College and one at the University of Wisconsin; and in 1959 a similarly limited and experimental program was started for college teachers. The in-service institutes were inaugurated in 1957 for high school teachers and in 1959 for elementary school teachers.

During this over-all period there has been rapid growth in the funds available for the institutes and subsequently in the number of institutes that could be provided. Because of the special interest of Congress in improvement opportunities for high school teachers of science and mathematics, in recent years a substantial percentage of the funds available for education in the sciences has been devoted to the institutes programs. The high point was in 1957, when the institutes accounted for 65.6 percent of the total program. With the large general increase in appropriations and the adjustment of program support, however, the share of total funds for institutes has declined currently to 51 percent, which brings it more nearly in balance with other programs. By the close of 1960 some 72,000 teachers will have participated in these programs.

It is still much too early to be able to make a valid assessment of these programs, but it is cause for some satisfaction that through this means a significant proportion of the secondary school teachers of science and mathematics will have had some opportunity to become informed about current trends in their fields, as well as an opportunity to become acquainted with new laboratory methods.

A fundamental and long-range problem, of course, is that of providing more adequate original training for such teachers. Clearly, we cannot expect to continue indefinitely "retraining" teachers whose preparatory training has been inadequate. This, however, is a problem that lies outside the foundation's purview and brings us back once more to the principle of local control of education; it is at the local level that the problem must be faced.



Artist's conception of the oceanographic research vessel to be built for the Woods Hole Oceanographic Institution under a $3 million grant from the National Science Foundation.

Special projects in science education. Programs included in this category are grouped generally as follows: (i) programs directed toward secondary school students; (ii) college programs and teacher-improvement programs; and (iii) public understanding of science.

Programs in the first category are designed to supplement the secondary school students' classroom training in science by providing visiting scientists, state academies of science, and summer training for students of special ability and aptitude. The program also makes available science materials, through the media of the traveling science libraries, and traveling science demonstration lectures. It supports cooperative college-school programs and school science clubs.

Under college and teacher-improvement programs, opportunities are provided for undergraduate students in science, mathematics, and engineering to obtain experience in research laboratories, through the undergraduate science education program. Students in small colleges are brought into contact with eminent scholars from other institutions through the visiting scientists program. To assist teachers, various experimental activities have been designed, such as conferences and special academic-year programs and the program for research participation.

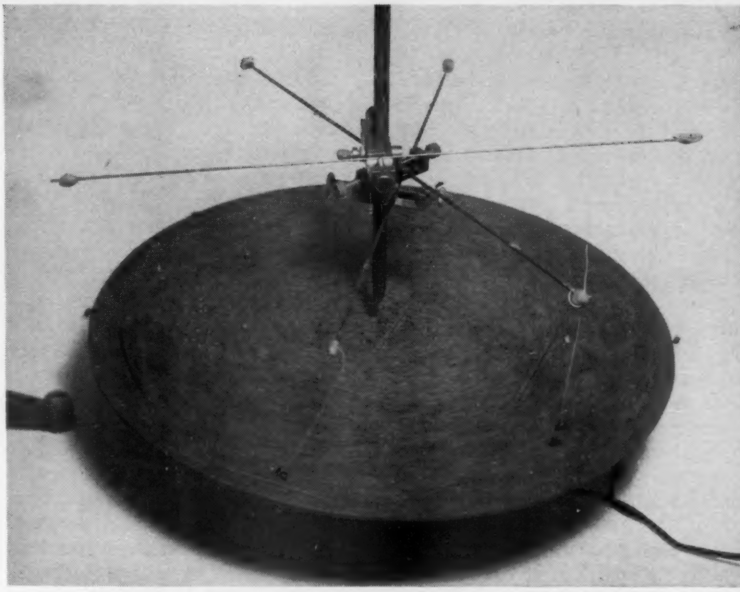
From a small beginning of $20,000 in 1953, support for the special projects rose slowly to something over $8.5 million in 1959 and more than $10 million in 1960. Increased support is based upon the expansion of old programs that have proved their worth and the apparent success of some of the new ones launched last year.

Public understanding of science. Progress in science depends to a considerable extent on public understanding and support of a sustained program of science education and research. At the present time, science is generally mistakenly identified in the public mind with the results of applied research and technology—spectacular developments such as space vehicles and weapons systems; with the applications of research to the cure of disease; and with the bewildering array of modern machines and gadgets that are advertised on every side.

There is inadequate understanding of the role of basic research and its fundamental relationship to progress in engineering and technology.

The foundation has broadly construed "education in the sciences" to include, also, education of the public. The increasing significance of science and technology in relation to public policy, both national and international, has made it urgent that the level of scientific literacy on the part of the general public be markedly raised. In order to participate fully in the democratic process through intelligent voting, citizens must have at least a general knowledge and understanding of the nature of science and its implications for the national defense and welfare.

This is a relatively new area, and there is little experience to guide us in the choice and methods and techniques that will serve the purpose. To date, the foundation has supported a limited number of conferences and institutes in which scientists and science writers have been brought together for the purpose of discussing the problems of communicating science to the layman. It is planned to expand these efforts and to enlist the support and advice of influential editors of the general-information media as well as the aid of the scientific community and such organizations as the AAAS and the professional scientific societies. The program was initiated in 1959 with a budget of $5000, but as much as $200,000 may be expended for these purposes by the end of 1960.



An interesting technique for studying the physiology of insect feeding, in a research project in the biological sciences, supported by the National Science Foundation. The turntable is used to "fly" flies to exhaustion in order to deplete the carbohydrate reserves. The flies are then fed a highly stimulating but nonnutritional sugar to test their hunger reactions.

Course content improvement. Comparable in importance to the need for aid to students and to teachers of science is the need for improvements in curriculums and course content. As a result of early studies of the subject, the dimensions of the problem began to emerge. Science must not be poorly taught at any level or in any field. Attention must therefore be given to the content of science and mathematics courses, from the elementary courses in general science through graduate courses in highly specialized fields.

The foundation has approached this problem in a number of ways. Support has been given to relatively small projects in limited areas where useful results can be anticipated. For example, the American Meteorological Society has been awarded a grant to enable its editorial board to prepare a series of monographs on such subjects as "The Earth and the Sun," "High Atmosphere," "Climate and Man," "Oceans and Air Currents," and other subjects designed to interest high school and college students in the field of meteorology.

At the other end of the scale, a high level of support has been given out-

standing investigators to enable them to attack a major problem in force. The work done by the Physical Sciences Study Committee at Massachusetts Institute of Technology is an example. This project, which was initiated in November 1956, has produced an entirely new approach to the teaching of physics, with a new syllabus, new textbooks, and a wide variety of new teaching aids and new methods and techniques of demonstration. The course was tried out experimentally in the 1957–58 school year, with eight teachers presenting the entire course. The number of teachers using the course has increased in each succeeding year, and special summer institutes supported by the foundation have trained teachers in its use. In September of 1960 the materials developed by the committee will be made available to all interested schools through Educational Services, Inc., of Watertown, Massachusetts, a nonprofit organization founded in September 1958.

The success of the course revision work in physics prompted a similar large-scale effort in mathematics, guided by the School Mathematics Study Group, operating with headquarters at Yale University. The chemistry curriculum is being worked on by two groups, the Chemical Bond Approach Committee at Earlham College and the Chemical Educational Materials Study at Harvey Mudd College. The Biological Sciences Curriculum Study has its headquarters at the University of Colorado.

Here again we have the pattern of an experimental beginning of only a few thousands of dollars up until 1957–58 (when the figures climbed above the half-million mark) and a continuing increase to the current year, in which it has seemed wise to invest $6 million in these programs.

The comprehensive review and revision of the four major science courses—physics, mathematics, chemistry, and biology—is unquestionably one of the most significant developments in the teaching of science in this country. Courses that are out of date by as much as 30 to 40 years are being brought abreast of modern developments. In the process of working together on this task, university scientists and secondary school teachers and administrators have come to see each other's problems and points of view as they could have in no other way.

Scientific Manpower Program

Responsibility for the operation and maintenance of the National Register of Scientific and Technical Personnel was transferred to the National Science Foundation by the foundation's enabling legislation. The register provides records of location and of training, scientific specializations, and other qualifications of approximately 185,000 selected scientists and engineers and is designed to insure that timely information is available, in case of need, on the numbers and characteristics of scientists and other technically trained persons in the United States. The foundation's scientific manpower section is also engaged in continuing studies designed to provide basic data on scientific and technical personnel generally. This program is currently being supported at a level somewhat below $1 million.

Other sources of federal support for education. In addition to the programs of the National Science Foundation, major contributions to science education are made by a number of other agencies, including the National Institutes of Health, the U.S. Office of Education, and the Atomic Energy Commission. The National Defense Education Act, for example, provides significant help under the graduate fellowship program, the student loan program, and to some extent under titles III and VII.

International Programs in Science

The scope of the foundation's international activities in science broadened considerably during the second half of the decade. The International Geophysical Year marked the first time that the foundation had participated in international scientific activities on a large scale, and it also represented the foundation's first opportunity to coordinate a major activity being undertaken by a number of government agencies. The scientific and technical program for the United States was developed and directed by the U.S. National Committee for the IGY, under the National Academy of Sciences. At the request of the academy, the foundation initiated consideration of IGY support by the federal government and, upon affirmative decision, secured and administered federal funds totaling $43.5 million. The foundation also served as coordinator of government interests in the program; these involved not only direct participation by government agencies but also, quite often, matters of broad national policy that arise in an international program.

As an aftermath of the IGY, both individuals and government agencies have been encouraged to carry on research that extends certain aspects of the IGY work. Under the general label of International Geophysical Cooperation, the program is being coordinated at the international level by the Comité International Géophysique of ICSU. This special committee is composed of the four unions principally involved: the International Union of Geodesy and Geophysics, the International Scientific Radio Union, the International Union of Astronomers, and the International Union of Pure and Applied Physics. So far as administration is concerned, the IGC is not a "package program." Instead, the foundation accepts proposals in areas where coordinated global research is of special importance, and these are then appraised as part of the regular program of research grants.

Antarctic research. A major outgrowth of the IGY has been the continuing research programs in the Antarctic being carried on by the 12 nations who participated in the IGY antarctic program. General scientific recommendations for the area are made by the Special Committee on Antarctic Research (SCAR) of ICSU. The United States program is being developed, funded, and coordinated by the National Science Foundation. The latter looks primarily to the Committee on Polar Research of the National Academy of Sciences for program recommendations, and the foundation also considers proposals from qualified scientists interested in carrying out such research. The foundation works with the Interdepartmental Committee on the Antarctic to coordinate the research activities of other agencies, such as the National Bureau of Standards, the Weather Bureau, and the Geological Survey, and provides them with funds for their participation in antarctic research. Grants are also made to universities and various interested research organizations to complete the program of scientific activities in the Antarctic. To date, Congress has ap-

propriated $10 million for the post-IGY program in the Antarctic.

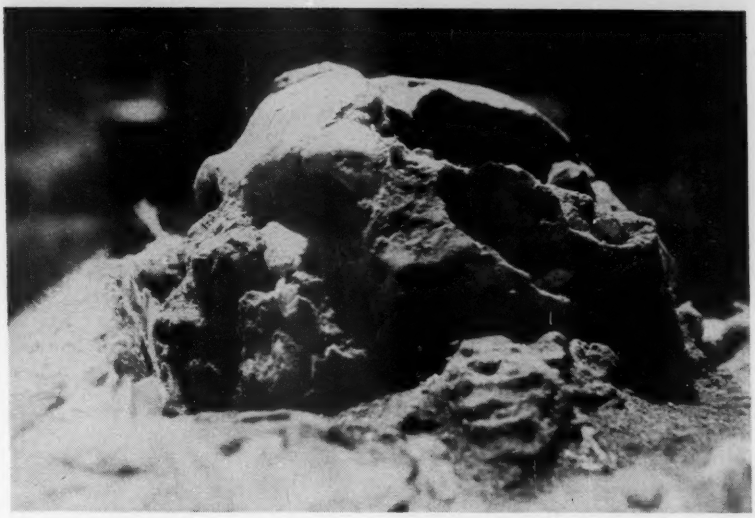
The Navy, which has from the beginning provided all logistic support for antarctic research, continues to do so with distinction under the new program and is in command of operations in the area. The cost of this logistic support is, of course, considerably greater than the cost of the actual scientific program.

International science education. Beginning in 1959, the foundation undertook a modest program designed to foster international cooperation and improve communications among nations with respect to problems of science education and scientific manpower. Appropriate professional groups in the various disciplines were given support for a study and evaluation of science subject matter offered in foreign educational systems, with the objective of improving science curriculums in this country. Distinguished foreign scholars were brought here to visit the various institutes sponsored by the foundation. Advanced students and scientists have received foundation support to permit them to participate in international educational programs. For example, a grant was made to the University of Uppsala, Sweden, for American participation in an international summer institute in quantum chemistry.

These various small programs have furnished experience that will guide us in the development and enlargement of future programs in international science education.

Other international scientific activities. Amendments to the National Science Foundation Act which were passed by Congress last year permit the foundation to cooperate in international *scientific* activities, whereas previously it was limited to *research* activities. The amendments also permit the foundation, with the approval of the Secretary of State, to grant fellowships or make other arrangements with foreign nationals for scientific study or scientific work in the United States. Under its existing and extended authority, and with the concurrence of the Secretary of State, the foundation plans to expand its international activities on a modest scale.

The foundation hopes to place, later on, appropriately qualified persons at overseas locations to carry out short-term studies in limited areas of science that are of interest and importance to



A 45,000-year-old skull uncovered during the excavation of Shanidar Cave in northern Iraq by an archeological expedition sponsored by the Smithsonian Institution and partially supported by the National Science Foundation. The skull is that of an adult Neanderthal man. The cranium had been struck by stones and displaced at the time of accidental death. The neck vertebrae are in the original position.

both the United States and the foreign country. Eventually, it is hoped, qualified persons can be placed overseas for longer periods for the purpose of conducting and maintaining continuous contact with the scientific communities of other countries.

As funds are made available, it may be possible, also, to afford greater support to certain appropriate types of research and research facilities abroad.

Science Information

The scope and importance of the scientific information problem is something of which the foundation has been aware since the beginning. Early attempts were made to study certain aspects of the problem, and, with the extremely limited funds available, support was given to small projects directed toward this end. This was increased as the over-all appropriation grew, but a really major effort in the field of scientific information was made possible by almost simultaneous action by the Executive and Legislative branches of government.

In December 1958 the White House released a special report of the President's Science Advisory Committee on "Improving the Availability of Scientific and Technical Information in the United States." After emphasizing the importance of the problem, the President's Committee recommended that the National Science Foundation expand its scientific information program to strengthen and coordinate existing governmental and private efforts in this field. This recommendation was later implemented by Executive Order No. 10807 of 13 March 1959. The National Defense Education Act of 1958, under title IX, directed the foundation to establish a science information service. The act also provided for the establishment of a 19-member Science Information Council whose members, government and nongovernment, would represent a broad range of skills and experience in the problems of the communications needs of scientists. The Office of Science Information Service was formally established in the foundation on 11 December 1958, and the Science Information Council first met in February 1959.

The program activities of the Office of Science Information Service fall generally in five categories: (i) storage and retrieval systems and mechanical translation; (ii) scientific publications; (iii) unpublished research information; (iv) scientific data and reference centers; and (v) foreign science information. Through these several programs the foundation seeks to increase the dissemination of existing materials by helping to provide for prompt publica-

A marine biologist currently working in the Antarctic under a National Science Foundation grant sets a wire fish trap at the ice edge near the McMurdo Sound Naval Air Facility. This is part of the U.S. Antarctic Research Program administered by the foundation.

tion of research results, for reference aids and information centers of various kinds, and for translations of significant scientific papers in languages not widely understood by American scientists.

Research on information problems. The foundation is supporting a slowly growing body of research on new approaches to the information problem. Most of the research is concerned with exploration of ways to use machines in information processing tasks, such as the organization, storage, and searching of scientific information and the translation of scientific publications from foreign languages into English. Before machines can process the texts of documents, however, for either mechanized information searching systems or mechanical translation systems, more precise knowledge of syntax and semantics is needed. Therefore, current research activities in these areas are extending our understanding of language in the expectation that ultimately machines will be able to handle linguistic data.

A Research Information Center and Advisory Service on Information Processing has been established jointly with the National Bureau of Standards, with some financial support from the Council on Library Resources. The purpose of the new center is to bring together research and development data on methods and equipment for the automatic processing of scientific information. The center will also endeavor to foster closer cooperation among the groups in industry, the private foundations, the universities, the professional societies, and the agencies of the federal government that are concerned with developing and improving methods for rapid and efficient handling of large volumes of information.

In this same area, the foundation is issuing regularly two publications designed to disseminate information on the scientific information field and foster cooperation among research workers in that field. *Current Research and Development in Scientific Documentation* is issued semiannually as a guide to current projects both here and abroad, while *Non-Conventional Technical Information Systems in Current Use* reports on information systems that embody new principles for the organization of subject matter or employ automatic equipment for storage and search.

In the support of scientific publications, temporary or emergency aid is given to primary journals and abstracting and indexing services; also, funds are provided for the preparation or publication of significant monographs, reviews, and reference works that could not be made generally available without subsidy.

Support of this kind is granted on the basis of the needs of the scientific community and sound economic planning for the publication.

Among the scientific journals partially supported by the foundation are two new experimental periodicals, *Physical Review Letters* and *Wildlife Disease*. The first is designed to provide rapid, low-cost publication of short, up-to-the-minute articles on physics research. The latter is the first journal to be published only in microform. The purpose of this journal is to explore author, reader, and librarian reaction to microform as a means of publishing research results at greatly reduced costs.

The foundation is also seeking to make unpublished research information more accessible. The principal sources of such information are research reports and memorandums of government and private institutions, theses and dissertations, and papers presented at scientific conferences. An example of foundation activities in this area is the recently initiated series of inventories of information activities of those federal agencies that operate major scientific information programs. Four surveys in this series, covering the Department of Agriculture, the Office of Naval Research, some programs of the Department of Commerce, and the Government Printing Office, have been published, and others are in various stages of preparation.

Two examples of data and reference centers supported by the foundation are the Office of Critical Tables (OCT) of the National Academy of Sciences and the Bio-Sciences Information Exchange (BSIE) of the Smithsonian Institution. The OCT, wholly supported by the foundation, is a coordinating and information center on projects engaged in developing critical physical data of all kinds. The BSIE, supported by the foundation and other interested agencies, functions as a repository of knowledge on "who is working on what" in the biological sciences.

Plans are now being developed, with the aid of the Federal Council on Science and Technology, for broadening the information exchange at the Smithsonian Institution to include the physical sciences and possibly, at a later date, the social sciences as well.

Foreign science information. The foundation is supporting the cover-to-cover translation of 35 key U.S.S.R. scientific journals. Support is also being given the Midwest Inter-Library Center

for the acquisition of approximately 2300 "hard-to-get" foreign biological and chemical journals.

A series of studies is being made that will provide information on the organization, characteristics, and generation of scientific information in every major geographic area of the world. Studies currently under way or planned concern the Soviet Union, Poland, Japan, Indonesia, mainland China, Czechoslovakia, Yugoslavia, and Hungary.

The foundation is coordinating a program, involving several federal agencies, whereby foreign currencies accruing to the U.S. Government through sales of surplus agricultural products will be used to support projects abroad for translating foreign-language publications into English.

In order to provide an effective means of exchanging information among groups working in the scientific information field, the foundation issues a bimonthly bulletin, *Science Information Notes*. This bulletin reports national and international developments and will, it is hoped, assist in promoting increased cooperation and coordination among scientific information services.

Conclusion

In any assessment of the role and accomplishments of the foundation during its first decade, it is necessary to consider the broader question of federal policy determination with respect to research support, research facilities, and the development and use of scientific manpower. Policy, in turn, must be evaluated in terms of (i) the general principles to be followed, (ii) the organization of the federal government for science and technology, and (iii) the effectiveness of the organization and operations in accomplishing the desired objectives. Let me summarize briefly the conclusions discussed above with respect to each of these points.

General principles. The first principle in national science policy, as interpreted by the foundation, is the critical importance of basic research for progress in science and technology. It is only through comprehensive support of basic research in all the fields of science that one can discover the potentialities for application that are so important in the competitive technology of today. Because basic research is an essential factor in the advanced training of scientists and engineers, and because the university is the natural home of basic research, it is clear that major attention must always be paid to the support of basic research in colleges and universities.

The support of basic research is relatively inexpensive. The significant costs of research and development arise out of expensive developmental programs, such as ballistic missiles, especially when these are undertaken on a "crash" basis. Since there is bound to be an upper limit to the amount of money available for science and technology, it is obvious that needed economies should be effected through careful selection of the developments to be undertaken. But it is false economy to curtail the basic research that uncovers leads for future developments.

In the support of basic research there are three important considerations: progress of science, development of the individual, and strengthening and development of the institutions where research is done.

By and large, the federal government has paid the most attention to the first two categories. The progress of science has been advanced by the so-called "research projects" system, which permits an individual or a group to pursue a scientific problem of its own choosing and which permits the agencies to support proposals selected from those submitted. The government has paid considerable attention to the development of the individual through fellowship and other educational programs and through special programs to improve science teaching and science courses.

A national problem to which the federal government has paid relatively little attention, however, is that of support for educational institutions to enable them to develop their own capabilities in science and engineering. Institutions have benefited greatly from government support of research projects and from awards, such as fellowships, to individuals, but they have received little aid of a sufficiently general type to enable them to carry out their own plans for growth in science and engineering and to maintain a proper balance between these activities and others in which they engage. The needs are great: Graduate research laboratories require modernization in terms of buildings, equipment, and space; the salary scale in many institutions urgently needs adjustment upward; there is a great and continuing shortage of maintenance and operating funds; in the secondary schools the salary problem is also acute, and although progress is being made, much still remains to be accomplished.

The federal government's policy with respect to the problems of the institutions is to point out the needs and to emphasize the importance of satisfying those needs, to the extent possible, from state and private sources in accordance with American traditions. But it is also the responsibility of the federal government to exercise leadership in meeting this problem. It is becoming increasingly clear that the inadequacy of the resources available to our educational institutions is a national problem and one which the federal government must help to meet. Another problem to which I have referred above is the growing need for evaluation and handling of competing claims in special areas of basic research which their supporters feel are critical. Atmospheric physics, oceanography, meteorology, and seismology are examples of areas that in recent years have been found to lack adequate support, trained personnel, facilities, and equipment. Special techniques may be required for handling such problem areas, but these special problems should not obscure the need for comprehensive support of basic research in all fields of science.

Organization of the federal government for greatest progress. In recent years there has been extensive discussion of the adequacy of the federal government's organization for dealing with matters of science and technology. At the present time, each government agency has its own organization for research and development. Over-all policy recommendations concerning the nation's effort and federal responsibilities for science in the strict meaning of the term are vested in the foundation and centered in its Presidentially-appointed National Science Board. The President's Science Advisory Committee considers critical scientific and technological matters relating to the national security and welfare; the Federal Council for Science and Technology is responsible for over-all long-range planning and matters of coordination in research and development activities among the federal agencies; science in foreign affairs is represented in the Department of

State by the Science Adviser to the Secretary; and finally, the Special Assistant to the President for Science and Technology makes immediately available to the President advice in any of those areas bearing upon critical questions of policy or action.

Effectiveness of organization and operations. In principle, the organization thus outlined should be able to deal with most fundamental issues involving science and technology with which the government is faced. On the record, many major issues have been met effectively, the cooperation of participating scientists has been outstanding, and progress along many lines has been noteworthy. However, part of this structure has not been operating long enough to evaluate its effectiveness.

In the meantime, suggestions have been made, especially in Congress, for a more radical type of organization—for example, a cabinet department for science and technology. If, by this, is meant a department that would assume complete responsibility for all research and development in the federal government, the suggestion can surely be dismissed as being completely impractical. Over-centralization of science in a department of this type would be strenuously opposed by all scientists and engineers as hostile to their basic philosophy, and by federal agencies as usurping their essential prerogatives and responsibilities.

If, on the other hand, the suggested department of science and technology were intended to provide supervision and control over the research and development activities of other federal agencies, it would encounter severe administrative difficulties as differences of opinion arose between it and the individual agencies. Under our form of government, no agency can be expected to exercise such a role, which properly belongs in the White House or in the Executive Office of the President.

A third suggestion, more limited in scope, is that there should be brought together in one department certain major research and development activities now operating as part of regular departments. Included would be such establishments as the United States Weather Bureau, the National Bureau of Standards, the Hydrographic Office, and the Geological Survey. Such a consolidation might well advance the research and development activities of these agencies but would leave the problem of what to do with their functions as service organizations to the departments in which they are presently located. It is to be hoped that inadequacies in the present situation that have given rise to this suggested plan can be remedied by constructive action of the departments concerned.

Admittedly there are problems of considerable magnitude to be solved in achieving maximum effectiveness in the organization and operations of the federal government with respect to science and technology. However, the greatest need at the moment, appears to be that of full support for the present organization, which is relatively new both in its over-all aspects and in the internal organization of individual agencies. In the charter for the Federal Council on Science and Technology, for example, it is provided that each member will speak authoritatively for his department or agency in matters pertaining to science and technology. A simple way of carrying out this provision would be for each department to appoint as its representative an Assistant Secretary for Research and Development, or someone in an equivalent position.

It must be remembered that the problem of large-scale government administration of science is recent, dating back only to World War II. We have had to feel our way into a whole new area of policy and operation. Scientists and engineers must be ready to accept full-time government posts and to acquire the training and background in administration that are essential to this new role. The agencies and departments, on the other hand, must accept the growing importance of science and technology and adapt their administrative structures to meet its needs. The problem is one that calls for great understanding as well as cooperation and good will on all sides.

A final word. Irrespective of individual opinions as to the manner in which the National Science Foundation is carrying out its assigned role, it cannot be denied that the importance of science in national affairs is such as to justify the establishment of an agency dedicated to the progress of basic research and education in the sciences. Nor will it be denied that the federal government should be increasingly concerned with the progress of science and technology, both in its own agencies and in the nation at large. The current estimated national expenditure of $12 billion on research and development would bear out this conclusion, even if more important considerations were not involved.

But it is also clear, that the whole responsibility cannot and should not rest with the federal government. It is essential that the citizens of the country understand and appreciate the importance of science and technology in all its phases, but especially the importance of basic research and education. Without the understanding and support of the people of the United States, the federal government will be unable to take proper measures for the adequate support of basic research and education in science. Individual voters, communities, and states must clearly recognize their responsibilities. The problems inherent in science and technology cannot be dismissed on the assumption that they can be met by the federal government without understanding, support, and local action by informed citizens.

References and Notes

1. D. Wolfle, *Science* **126**, 335 (1957).
2. This executive order was later amended by Executive Order 10807, 13 March 1959.

Some Moral and Technical Consequences of Automation

As machines learn they may develop unforeseen strategies at rates that baffle their programmers.

Norbert Wiener

Some 13 years ago, a book of mine was published by the name of *Cybernetics*. In it I discussed the problems of control and communication in the living organism and the machine. I made a considerable number of predictions about the development of controlled machines and about the corresponding techniques of automatization, which I foresaw as having important consequences affecting the society of the future. Now, 13 years later, it seems appropriate to take stock of the present position with respect to both cybernetic technique and the social consequences of this technique.

Before commencing on the detail of these matters, I should like to mention a certain attitude of the man in the street toward cybernetics and automatization. This attitude needs a critical discussion, and in my opinion it should be rejected in its entirety. This is the assumption that machines cannot possess any degree of originality. This frequently takes the form of a statement that nothing can come out of the machine which has not been put into it. This is often interpreted as asserting that a machine which man has made must remain continually subject to man, so that its operation is at any time open to human interference and to a change in policy. On the basis of such an attitude, many people have pooh-poohed the dangers of machine techniques, and they have flatly contradicted the early predictions of Samuel Butler that the machine might take over the control of mankind.

It is true that in the time of Samuel Butler the available machines were far less hazardous than machines are today, for they involved only power, not a certain degree of thinking and communication. However, the machine techniques of the present day have invaded the latter fields as well, so that the actual machine of today is very different from the image that Butler held, and we cannot transfer to these new devices the assumptions which seemed axiomatic a generation ago. I find myself facing a public which has formed its attitude toward the machine on the basis of an imperfect understanding of the structure and mode of operation of modern machines.

It is my thesis that machines can and do transcend some of the limitations of their designers, and that in doing so they may be both effective and dangerous. It may well be that in principle we cannot make any machine the elements of whose behavior we cannot comprehend sooner or later. This does not mean in any way that we shall be able to comprehend these elements in substantially less time than the time required for operation of the machine, or even within any given number of years or generations.

As is now generally admitted, over a limited range of operation, machines act far more rapidly than human beings and are far more precise in performing the details of their operations. This being the case, even when machines do not in any way transcend man's intelligence, they very well may, and often do, transcend man in the performance of tasks. An intelligent understanding of their mode of performance may be delayed until long after the task which they have been set has been completed.

This means that though machines are theoretically subject to human criticism, such criticism may be ineffective until long after it is relevant. To be effective in warding off disastrous consequences, our understanding of our man-made machines should in general develop *pari passu* with the performance of the machine. By the very slowness of our human actions, our effective control of our machines may be nullified. By the time we are able to react to information conveyed by our senses and stop the car we are driving, it may already have run head on into a wall.

Game-Playing

I shall come back to this point later in this article. For the present, let me discuss the technique of machines for a very specific purpose: that of playing games. In this matter I shall deal more particularly with the game of checkers, for which the International Business Machines Corporation has developed very effective game-playing machines.

Let me say once for all that we are not concerned here with the machines which operate on a perfect closed theory of the game they play. The game theory of von Neumann and Morgenstern may be suggestive as to the operation of actual game-playing machines, but it does not actually describe them.

In a game as complicated as checkers, if each player tries to choose his play in view of the best move his opponent can make, against the best response he can give, against the best response his opponent can give, and so on, he will have taken upon himself an impossible task. Not only is this humanly impossible but there is actually no reason to suppose that it is the best policy against the opponent by whom he is faced, whose limitations are equal to his own.

The von Neumann theory of games bears no very close relation to the theory by which game-playing machines operate. The latter corresponds much more closely to the methods of play used by expert but limited human chess players against other chess players. Such players depend on certain strategic evaluations, which are in essence not complete. While the von Neumann type of play is valid for games like ticktacktoe, with a complete theory, the very interest of chess and checkers lies in the fact that they

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do not possess a complete theory. Neither do war, nor business competition, nor any of the other forms of competitive activity in which we are really interested.

In a game like ticktacktoe, with a small number of moves, where each player is in a position to contemplate all possibilities and to establish a defense against the best possible moves of the other player, a complete theory of the von Neumann type is valid. In such a case, the game must inevitably end in a win for the first player, a win for the second player, or a draw.

I question strongly whether this concept of the perfect game is a completely realistic one in the cases of actual, nontrivial games. Great generals like Napoleon and great admirals like Nelson have proceeded in a different manner. They have been aware not only of the limitations of their opponents in such matters as materiel and personnel but equally of their limitations in experience and in military know-how. It was by a realistic appraisal of the relative inexperience in naval operations of the continental powers as compared with the highly developed tactical and strategic competence of the British fleet that Nelson was able to display the boldness which pushed the continental forces off the seas. This he could not have done had he engaged in the long, relatively indecisive, and possibly losing conflict to which his assumption of the best possible strategy on the part of his enemy would have doomed him.

In assessing not merely the materiel and personnel of his enemies but also the degree of judgment and the amount of skill in tactics and strategy to be expected of them, Nelson acted on the basis of their record in previous combats. Similarly, an important factor in Napoleon's conduct of his combat with the Austrians in Italy was his knowledge of the rigidity and mental limitations of Würmser.

This element of experience should receive adequate recognition in any realistic theory of games. It is quite legitimate for a chess player to play, not against an ideal, nonexisting, perfect antagonist, but rather against one whose habits he has been able to determine from the record. Thus, in the theory of games, at least two different intellectual efforts must be made. One is the short-term effort of playing with a determined policy for the individual game. The other is the examination of a record of many games. This record has been set by the player himself, by his opponent, or even by players with whom he has not personally played. In terms of this record, he determines the relative advantages of different policies as proved over the past.

There is even a third stage of judgment required in a chess game. This is expressed at least in part by the length of the significant past. The development of theory in chess decreases the importance of games played at a different stage of the art. On the other hand, an astute chess theoretician may estimate in advance that a certain policy currently in fashion has become of little value, and that it may be best to return to earlier modes of play to anticipate the change in policy of the people whom he is likely to find as his opponents.

Thus, in determining policy in chess there are several different levels of consideration which correspond in a certain way to the different logical types of Bertrand Russell. There is the level of tactics, the level of strategy, the level of the general considerations which should have been weighed in determining this strategy, the level in which the length of the relevant past—the past within which these considerations may be valid—is taken into account, and so on. Each new level demands a study of a much larger past than the previous one.

I have compared these levels with the logical types of Russell concerning classes, classes of classes, classes of classes of classes, and so on. It may be noted that Russell does not consider statements involving all types as significant. He brings out the futility of such questions as that concerning the barber who shaves all persons, and only those persons, who do not shave themselves. Does he shave himself? On one type he does, on the next type he does not, and so on, indefinitely. All such questions involving an infinity of types may lead to unsolvable paradoxes. Similarly, the search for the best policy under all levels of sophistication is a futile one and must lead to nothing but confusion.

These considerations arise in the determination of policy by machines as well as in the determination of policy by persons. These are the questions which arise in the programming of programming. The lowest type of game-playing machine plays in terms of a certain rigid evaluation of plays. Quantities such as the value of pieces gained or lost, the command of the pieces, their mobility, and so on, can be given numerical weights on a certain empirical basis, and a weighting may be given on this basis to each next play conforming to the rules of the game. The play with the greatest weight may be chosen. Under these circumstances, the play of the machine will seem to its antagonist—who cannot help but evaluate the chess personality of the machine—a rigid one.

Learning Machines

The next step is for the machine to take into consideration not merely the moves as they occurred in the individual game but the record of games previously played. On this basis, the machine may stop from time to time, not to play but to consider what (linear or nonlinear) weighting of the factors which it has been given to consider would correspond best to won games as opposed to lost (or drawn) games. On this basis, it continues to play with a new weighting. Such a machine would seem to its human opponent to have a far less rigid game personality, and tricks which would defeat it at an earlier stage may now fail to deceive it.

The present level of these learning machines is that they play a fair amateur game at chess but that in checkers they can show a marked superiority to the player who has programmed them after from 10 to 20 playing hours of working and indoctrination. They thus most definitely escape from the completely effective control of the man who has made them. Rigid as the repertory of factors may be which they are in a position to take into consideration, they do unquestionably—and so say those who have played with them—show originality, not merely in their tactics, which may be quite unforeseen, but even in the detailed weighting of their strategy.

As I have said, checker-playing machines which learn have developed to the point at which they can defeat the programmer. However, they appear still to have one weakness. This lies in the end game. Here the machines are somewhat clumsy in determining the best way to give the *coup de grâce*. This is due to the fact that the existing machines have for the most part adopted a program in

which the identical strategy is carried out at each stage of the game. In view of the similarity of values of pieces in checkers, this is quite natural for a large part of the play but ceases to be perfectly relevant when the board is relatively empty and the main problem is that of moving into position rather than that of direct attack. Within the frame of the methods I have described it is quite possible to have a second exploration to determine what the policy should be after the number of pieces of the opponent is so reduced that these new considerations become paramount.

Chess-playing machines have not, so far, been brought to the degree of perfection of checker-playing machines, although, as I have said, they can most certainly play a respectable amateur game. Probably the reason for this is similar to the reason for their relative efficiency in the end game of checkers. In chess, not only is the end game quite different in its proper strategy from the mid-game but the opening game is also. The difference between checkers and chess in this respect is that the initial play of the pieces in checkers is not very different in character from the play which arises in the mid-game, while in chess, pieces at the beginning have an arrangement of exceptionally low mobility, so that the problem of deploying them from this position is particularly difficult. This is the reason why opening play and development form a special branch of chess theory.

There are various ways in which the machine can take cognizance of these well-known facts and explore a separate waiting strategy for the opening. This does not mean that the type of game theory which I have here discussed is not applicable to chess but merely that it requires much more consideration before we can make a machine that can play master chess. Some of my friends who are engaged in these problems believe that this goal will be achieved in from 10 to 25 years. Not being a chess expert, I do not venture to make any such predictions on my own initiative.

It is quite in the cards that learning machines will be used to program the pushing of the button in a new push-button war. Here we are considering a field in which automata of a non-learning character are probably already in use. It is quite out of the question to program these machines on the basis of an actual experience in real war. For one thing, a sufficient experience to give an adequate programming would probably see humanity already wiped out.

Moreover, the techniques of push-button war are bound to change so much that by the time an adequate experience could have been accumulated, the basis of the beginning would have radically changed. Therefore, the programming of such a learning machine would have to be based on some sort of war game, just as commanders and staff officials now learn an important part of the art of strategy in a similar manner. Here, however, if the rules for victory in a war game do not correspond to what we actually wish for our country, it is more than likely that such a machine may produce a policy which would win a nominal victory on points at the cost of every interest we have at heart, even that of national survival.

Man and Slave

The problem, and it is a moral problem, with which we are here faced is very close to one of the great problems of slavery. Let us grant that slavery is bad because it is cruel. It is, however, self-contradictory, and for a reason which is quite different. We wish a slave to be intelligent, to be able to assist us in the carrying out of our tasks. However, we also wish him to be subservient. Complete subservience and complete intelligence do not go together. How often in ancient times the clever Greek philosopher slave of a less intelligent Roman slaveholder must have dominated the actions of his master rather than obeyed his wishes! Similarly, if the machines become more and more efficient and operate at a higher and higher psychological level, the catastrophe foreseen by Butler of the dominance of the machine comes nearer and nearer.

The human brain is a far more efficient control apparatus than is the intelligent machine when we come to the higher areas of logic. It is a self-organizing system which depends on its capacity to modify itself into a new machine rather than on ironclad accuracy and speed in problem-solving. We have already made very successful machines of the lowest logical type, with a rigid policy. We are beginning to make machines of the second logical type, where the policy itself improves with learning. In the construction of operative machines, there is no specific foreseeable limit with respect to logical type, nor is it safe to make a pronouncement about the exact level at which the brain is superior to the machine. Yet for a long time at least there will always be some level at which the brain is better than the constructed machine, even though this level may shift upwards and upwards.

It may be seen that the result of a programming technique of automatization is to remove from the mind of the designer and operator an effective understanding of many of the stages by which the machine comes to its conclusions and of what the real tactical intentions of many of its operations may be. This is highly relevant to the problem of our being able to foresee undesired consequences outside the frame of the strategy of the game while the machine is still in action and while intervention on our part may prevent the occurrence of these consequences.

Here it is necessary to realize that human action is a feedback action. To avoid a disastrous consequence, it is not enough that some action on our part should be sufficient to change the course of the machine, because it is quite possible that we lack information on which to base consideration of such an action.

In neurophysiological language, ataxia can be quite as much of a deprivation as paralysis. A patient with locomotor ataxia may not suffer from any defect of his muscles or motor nerves, but if his muscles and tendons and organs do not tell him exactly what position he is in, and whether the tensions to which his organs are subjected will or will not lead to his falling, he will be unable to stand up. Similarly, when a machine constructed by us is capable of operating on its incoming data at a pace which we cannot keep, we may not know, until too late, when to turn it off. We all know the fable of the sorcerer's apprentice, in which the boy makes the broom carry water in his master's absence, so that it is on the point of drowning him when his master reappears. If the boy had had to seek a charm to stop the mischief in the *grimoires* of his master's library, he might have been drowned before he had discovered the relevant incantation. Similarly, if a bottle factory is programmed on the basis of maximum productivity, the

owner may be made bankrupt by the enormous inventory of unsalable bottles manufactured before he learns he should have stopped production six months earlier.

The "Sorcerer's Apprentice" is only one of many tales based on the assumption that the agencies of magic are literal-minded. There is the story of the genie and the fisherman in the *Arabian Nights,* in which the fisherman breaks the seal of Solomon which has imprisoned the genie and finds the genie vowed to his own destruction; there is the tale of the "Monkey's Paw," by W. W. Jacobs, in which the sergeant major brings back from India a talisman which has the power to grant each of three people three wishes. Of the first recipient of this talisman we are told only that his third wish is for death. The sergeant major, the second person whose wishes are granted, finds his experiences too terrible to relate. His friend, who receives the talisman, wishes first for £200. Shortly thereafter, an official of the factory in which his son works comes to tell him that his son has been killed in the machinery and that, without any admission of responsibility, the company is sending him as consolation the sum of £200. His next wish is that his son should come back, and the ghost knocks at the door. His third wish is that the ghost should go away.

Disastrous results are to be expected not merely in the world of fairy tales but in the real world wherever two agencies essentially foreign to each other are coupled in the attempt to achieve a common purpose. If the communication between these two agencies as to the nature of this purpose is incomplete, it must only be expected that the results of this cooperation will be unsatisfactory. If we use, to achieve our purposes, a mechanical agency with whose operation we cannot efficiently interfere once we have started it, because the action is so fast and irrevocable that we have not the data to intervene before the action is complete, then we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorful imitation of it.

Time Scales

Up to this point I have been considering the quasi-moral problems caused by the simultaneous action of the machine and the human being in a joint enterprise. We have seen that one of the chief causes of the danger of disastrous consequences in the use of the learning machine is that man and machine operate on two distinct time scales, so that the machine is much faster than man and the two do not gear together without serious difficulties. Problems of the same sort arise whenever two control operators on very different time scales act together, irrespective of which system is the faster and which system is the slower. This leaves us the much more directly moral question: What are the moral problems when man as an individual operates in connection with the controlled process of a much slower time scale, such as a portion of political history or—our main subject of inquiry—the development of science?

Let it be noted that the development of science is a control and communication process for the long-term understanding and control of matter. In this process 50 years are as a day in the life of the individual. For this reason, the individual scientist must work as a part of a process whose time scale is so long that he himself can only contemplate a very limited sector of it. Here, too, communication between the two parts of a double machine is difficult and limited. Even when the individual believes that science contributes to the human ends which he has at heart, his belief needs a continual scanning and re-evaluation which is only partly possible. For the individual scientist, even the partial appraisal of this liaison between the man and the process requires an imaginative forward glance at history which is difficult, exacting, and only limitedly achievable. And if we adhere simply to the creed of the scientist, that an incomplete knowledge of the world and of ourselves is better than no knowledge, we can still by no means always justify the naive assumption that the faster we rush ahead to employ the new powers for action which are opened up to us, the better it will be. We must always exert the full strength of our imagination to examine where the full use of our new modalities may lead us.

Science in the News

The Jackson Committee: Educating the Next President and the Next Congress

The most civilized, and perhaps the most important, current congressional investigation is that being conducted by Sen. Henry Jackson (D-Wash.) and his Subcommittee on National Policy Machinery. Its purpose, in part, is the unusual one of educating the next president to the pitfalls involved in organizing his bewilderingly complex job.

The committee also hopes to develop legislation, where legislation might be helpful, to smooth the president's problem. Perhaps more important, the committee hopes to build a case for reorganizing certain procedures, particularly in the area of the budget, which clearly need alteration, but which are likely to remain unchanged until basic attitudes in Congress are gradually changed.

James Reston, of the New York *Times*, has described the committee's efforts as "legislative investigation at its very best . . . scholarly, objective and nonpartisan." A measure of Jackson's success in meeting these refreshing standards is that the minority counsel, present to see that the witnesses put on record their estimates of the strong as well as weak points of the administration, has very little to do. This has not been because the committee has failed so far to uncover any areas of weakness, but because the committee has so

far resisted the temptation to label the weaknesses as specifically the weaknesses of a Republican administration.

A Basic Attitude

Nevertheless, even granting the committee an unusual degree of nonpartisanship, it is going to be difficult to draw a clear distinction between the investigation as a study of the policy-making flaws of the government and as a study of the weaknesses of the present administration.

In part, this is in the nature of things. After all, the most recent eight of the 13 years under study have been the Eisenhower years, and it is not only natural to concentrate the study on the more recent years, but there is the familiar tendency to regard the more distant past, in this case the Truman administration, as the good old days.

But quite aside from this, it has become clear that a major theme is going to be the illusory value of the elaborate organization, the dependence on committees, and the emphasis on team play and group thinking that, justly or unjustly, has become identified as the "Eisenhower style."

Individual versus Committees

A good deal of the testimony heard so far amounts to an endorsement of George Kennan's 1958 statement in *Daedalus* that "thought is, by its very nature, an individual process, not a collective one; to be useful thought must be communicated; to be communicated it must pass through the filter of the single mind that puts it into words; it cannot, therefore, be greater than what a single mind can comprehend and state. There is thus no such thing as collective judgment; there is only individual judgment, enriched and refined on occasion by the advice of others, and commanding, in certain cases, the approval of a wider body. This being the case, the pretense of a collective wisdom underlying so much of the governmental committee system today is simply a form of play acting and self-deception. . . . It leads to a complete sacrifice of incisiveness and style . . . in the broad sense of the style of statemanship itself, which can never be expressive and convincing unless it is the product of a single human personality."

Scientists Testify

There seemed to be a general agreement with Kennan's position among the seven scientists and scientific administrators who testified last week. This showed up in their unanimous distaste for the idea of a Department of Science, which they appeared to regard as little more than a committee to end all committees, with a mission so broad that it would be impossible to define, and a vague sense of authority over almost everything and actual operating responsibility for almost nothing.

It showed up again in statements such as physicist Edward Purcell's remark that "you have to keep new knowledge and new ideas as the goal, not regular reports and administrative tidiness." Purcell suggested that there can be too much concern about making sure the man at one end of the corridor knows what the man at the other end is doing; that, in research, at least, there comes a time when the most important thing to do is to leave the man alone.

Coordinating Points of View

No one questioned the importance of military planners understanding the international implications of what they are doing, of State Department people taking into account the repercussions of the newest developments in science and technology. Indeed, one of the key purposes of the inquiry is to seek the best ways that this can be done. But there was a general feeling that elaborate interdepartmental committees, advisory groups, and special staffs are not a sufficient answer. These were recognized as useful, but it became clear that the witnesses felt that there was already enough machinery of this sort.

There was so much of this machinery, in fact, that a disturbing portion of a policy-maker's time is occupied with obtaining the seemingly endless round of "concurrences" before a decision can be taken. As former Defense Secretary Robert Lovett told the committee in February, what was intended to be a policeman seems to be becoming a jail-keeper.

It was suggested that, rather than more machinery, what was needed was more men in the State Department, for example, who would command as part of their personal equipment a general if not a specialist's sophistication in sci-

Senator Henry Jackson (right) talking with James Fisk, president of Bell Telephone Laboratories and vice-chairman of the President's Science Advisory Committee. Other witnesses before the Jackson Committee last week included: William H. Pickering, director of the Jet Propulsion Laboratory at the California Institute of Technology and a member of the Army's Science Advisory Panel; physicist Edward M. Purcell, a Nobel prize winner and member of the President's Science Advisory Committee: Eugene P. Wigner, professor of physics at Princeton and a leading authority on nuclear reactors; Ruben F. Mettler, operating chief of Space Technology Laboratories, which handles a major share of the work of the U.S. space program; James A. Perkins, vice-president of the Carnegie Corporation and a member of the committee which prepared the Gaither Report on U.S. defense security; and Herbert F. York, recently appointed director of Research and Engineering in the Department of Defense.

entific and military matters. For the most frequent point made was that strong decisions were made by individual men, not by committees; and that the policy-maker should have sufficient understanding of areas outside his specialty to be able to use committees of specialists to gather facts without abdicating his authority to such committees.

Further Hearings

This awareness that good policy-makers are more important than good policy-making machinery has led the committee to schedule hearings for this month on the problems of getting outstanding men from industry and the universities into government service, and keeping them for longer periods of time. Later in the month the committee plans a detailed examination of the National Security Council, the key advisory body to the President.

Meanwhile, the committee today is only at the stage of getting the feel of the problems it wants to study. What it has done so far has been useful; but its final importance is probably going to depend on its ability to go beyond generalized recommendations to compile an impressive and rather detailed body of material demonstrating the conditions under which the country has gotten clear and effective decision-making, and the conditions where weak and vacillating policy decisions have resulted.

Academy Honors Waterman; New Officers and Members Elected

Alan T. Waterman, director of the National Science Foundation, received the Public Welfare Medal of the National Academy of Sciences during the 97th annual meeting of the academy, 25–27 April, in Washington. The medal, which is awarded for "eminence in the application of science to the public welfare," is considered to be the most distinguished of the academy's medals. It is unique among them in that it is awarded for outstanding public service in the uses of science, rather than achievements within a particular scientific discipline.

Officers Elected

Lloyd V. Berkner, president of Associated Universities, Inc., in New York City, was elected to a 4-year term as

Alan T. Waterman

treasurer of the academy. Also elected, for 3-year terms, were two new members of the academy's council—G. Evelyn Hutchinson, Sterling professor of zoology, Yale University, and Robley C. Williams, professor of virology and research biophysicist, University of California. The two retiring councilors are Frederick Seitz and Harry L. Shapiro.

New Members

Thirty-five new members were elected to the academy during the annual meeting. Election to the academy, which is on the basis of distinguished and continued achievements in original research, is considered to be one of the highest honors which can be visited upon an American scientist.

The new members are as follows. Herbert L. Anderson, professor of physics and director of the University of Chicago's Enrico Fermi Institute for Nuclear Studies; Allen V. Astin, director, National Bureau of Standards; Nicolaas Bloembergen, professor of applied physics, Harvard University; Alfred T. Blomquist, professor of organic chemistry, Cornell University; Henry G. Booker, professor of electrical engineering, Cornell University; Armin C. Braun, member and professor of bacteriology, Rockefeller Institute; Owen Chamberlain, professor of physics, University of California; Norman R. Davidson, professor of chemistry, California Institute of Technology; William Feller, Higgins professor of mathematics, Princeton University; Herbert Friedman, superintendent, atmosphere and astrophysics division, U.S. Naval Research Laboratory.

Robert Galambos, chief, department of neurophysiology, Walter Reed Army Institute of Research; Murray Gell-Mann, professor of theoretical physics, California Institute of Technology; Donald R. Griffin, professor of zoology, Harvard University; Herbert S. Gutowsky, professor of physical chemistry, University of Illinois; Bernard Haurwitz, professor of astrogeophysics, University of Colorado, and associate oceanographer, Woods Hole Oceanographic Institution; Hollis D. Hedberg, professor of geology, Princeton University; Karl F. Herzfeld, professor of physics and head of department, Catholic University; Carl I. Hovland, Sterling professor of psychology, Yale University; Robert J. Huebner, chief, Laboratory of Infectious Diseases, National Institute of Allergy and Infectious Diseases; Augustus B. Kinzel, vice president in charge of research, Union Carbide and Carbon Corporation.

Salvador E. Luria, professor of microbiology and chairman, Microbiology Committee, Massachusetts Institute of Technology; Daniel Mazia, professor of zoology, University of California at Berkeley; Stanford Moore, member and professor of biochemistry, Rockefeller Institute; Theodore T. Puck, professor of biophysics and head of department, University of Colorado Medical School; Roger W. Sperry, Hixon professor of psychobiology, California Institute of Technology; William H. Stein, member and professor of biochemistry, Rockefeller Institute; Wilson S. Stone, professor of zoology and director of gene research, University of Texas; Gilbert J. Stork, professor of chemistry, Columbia University; Richard N. Tousey, head, rocket spectroscopy branch, atmosphere and astrophysics division, U.S. Naval Research Laboratory; Jerome B. Wiesner, professor of electrical engineering, Massachusetts Institute of Technology and director, Research Laboratory of Electronics; Gordon R. Willey, Bowditch professor of Central American and Mexican archaeology, Harvard University; Carroll M. Williams, chairman, department of biology, Harvard University; Olin C. Wilson, astronomer, Mount Wilson and Palomar observatories; Clinton N. Woolsey, Charles Sumner Slichter research professor of neurophysiology, Medical School and Graduate School, University of Wisconsin; and Antoni Zygmund, professor of mathematics, University of Chicago.

Two Expeditions Announced by Scripps Institution

Between 15 June and 23 August the University of California's Scripps Institution of Oceanography at La Jolla, Calif., will send the *Spencer F. Baird* on an expedition to the central and equatorial Pacific area lying between Hawaii and the U.S. mainland. The purposes of this cruise are twofold, biological and geological. The cruise will be divided into three phases. Phases 1 and 3 will be devoted to biology and hydrography; phase 2 is primarily geological.

Sampling in phases 1 and 3 will consist of a series of deep mid-water trawls, opening-closing plankton tows, and hydrographic casts. It is anticipated that several of the hydrographic casts will be made to the maximum possible depths and, in addition, that a few replicate casts may be made. A series of gravity cores will also be taken.

Phase 2 will be devoted to an intensive bottom coring program to the south of Hawaii. Sediment samples collected by the *Challenger* in 1875 and the "Mid-Pacific" expedition in 1950 indicate the presence of extensive or numerous outcrops of fossiliferous Lower Tertiary sediments. Some 60 sediment cores will be taken in this area in an attempt to determine the conditions under which the older sediments outcrop. From this it may be possible to deduce some of the characters of the physical agents moving sediments in this area.

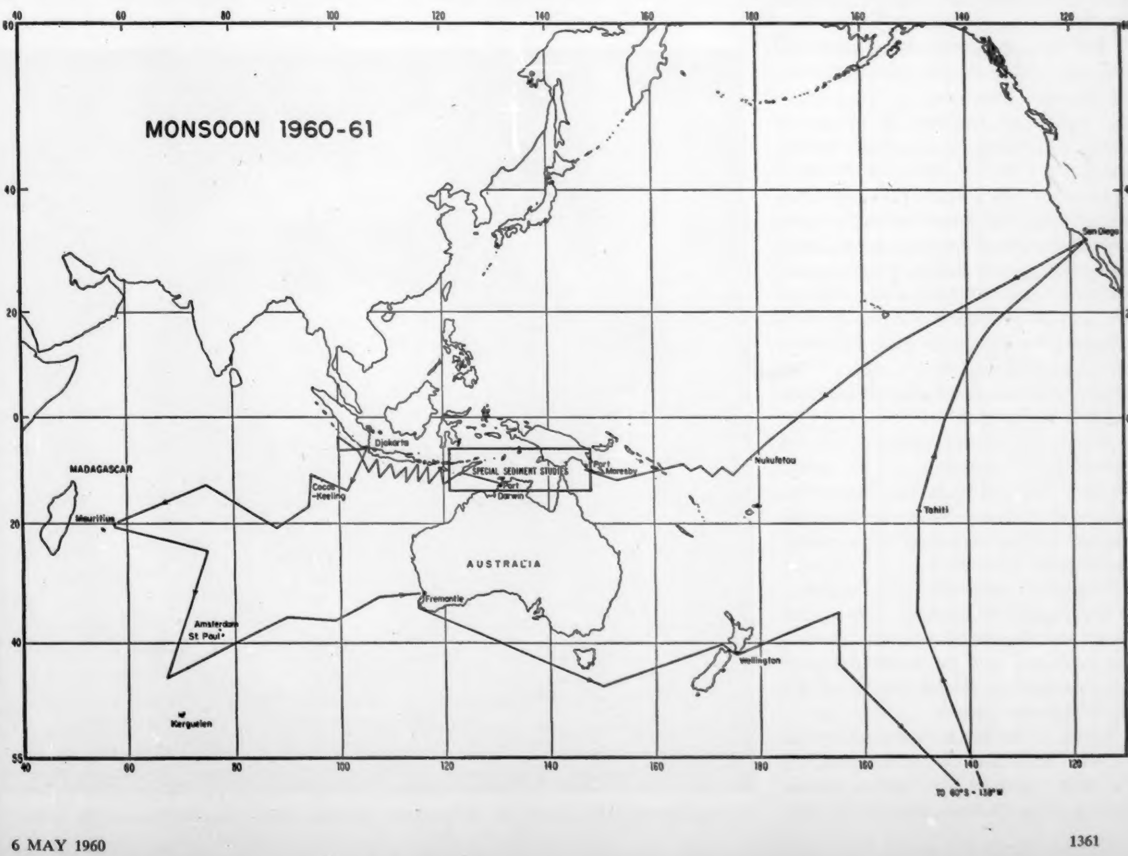
Although the biological and hydrographic data to be collected will have a direct bearing on a number of studies now in progress, the primary biological objective of the expedition is to investigate the distribution and ecology of meso- and bathypelagic organisms. The distribution of epipelagic organisms is a reflection of the circulation patterns, and consequently several of these organisms have proved to be useful as indicators. There is good reason to believe that living forms at greater depths are adapted to a particular spectrum of physical conditions and that their occurrence is limited by these conditions. By extending knowledge of the distribution and abundance of these forms, it may be possible to find correlations with the properties of the deep water and the circulation pattern.

Monsoon Expedition

Another Scripps expedition is scheduled for the period August 1960 to February 1961, when a research vessel will sail to the southwestern Pacific and southern Indian Ocean. The expedition, called Monsoon, will have a scientific program similar to those of the 1952–53 Capricorn and the 1957–58 Downwind investigations of the south and southeast Pacific, respectively.

The ship's program will include the following types of study in a portion of the southwest Pacific, part of the East Indian Archipelago, and the south equatorial and temperate regions of the Indian Ocean: bathymetric, sonoprobe seismic-refraction, magnetic, heat-flow, bottom-sampling, bottom-photography, hydrographic, and gravity reconnaissance studies. Measurements of CO_2 in the atmosphere and near-surface water will be made throughout the cruise.

Large-volume water sampling and radio-isotope and trace-element studies



will be carried out, especially during the equatorial and southwestern Pacific portions of the trip. The biological program will consist of plankton sampling throughout the cruise and of mid-water trawls and dredging for benthic organisms in the southwest Pacific and the Indian Ocean.

An earlier announcement of Monsoon's program and track, released in April 1959, indicated that a large portion of the cruise would be in the northwest Pacific and that no investigations would be carried out in the southwest Pacific. Monsoon Expedition, as now planned, includes much more extensive explorations in the Indian Ocean than had been formerly suggested. The northwest Pacific investigations proposed earlier will be carried out at a later date, possibly in the spring and summer of 1961.

Monsoon's investigations of the southern and central Indian Ocean will provide reconnaissance of part of the basin prior to the large-scale, multination cooperative International Indian Ocean Expedition of 1960–64, proposed by SCOR. Monsoon will be Scripps Institution's initial contribution to that joint effort.

The program outlined here covers the 6-month period that provides the best chance for good weather throughout the cruise. Observations will be carried out along a track of more than 35,000 miles.

Monsoon will employ the newly converted research vessel *ARS-27*, using her auxiliary boat for seismic-refraction shooting, detailed sounding on stations, and exploration of shoal areas. Perhaps the *ARS-27* will work in company with a research vessel of another nation in the Indonesia-Australia region. The *ARS-27* will accommodate a scientific party of 23 to 25.

About 18 marine scientists, chiefly from Scripps Institution, will be needed to carry out the basic program. Thus there will be room, and facilities, for several visiting scientists from other countries or laboratories.

A tentative schematic track is shown in the figure. Suggestions for participation in the expedition are invited, and provision will be made for such participation in so far as time and ship's capacity permit.

Robert L. Fisher is coordinating the over-all Monsoon scientific program and will supervise the Indian Ocean investigations. George Shor, T. H. van Andel, and Henry W. Menard will head the San Diego-Port Moresby, the Arafura Shelf, and the Wellington-San Diego segments of Monsoon, respectively.

X-Ray Picture of the Sun Taken from a Rocket

Most x-ray radiation reaching the earth is absorbed in the upper atmosphere, where it creates the belts of ionized air that make long-range radio transmission possible. The picture on this page, therefore, had to be taken from a rocket fired 130 miles into the outer reaches of the atmosphere. It shows the sun as our eyes would see it if they responded to x-rays rather than the longer wavelength radiation we call light.

A glass lens cannot be used to focus x-rays (the rays will simply pass through the glass unrefracted); the scientists, therefore, had recourse to the primitive pinhole camera, which has no lens at all. The camera works because only a single beam of light from each point on the object can pass through the hole, so forming a point-to-point relationship between the object and an image that is formed on a screen behind the pinhole.

In this case the hole was 0.005 inches wide, and an extremely thin aluminum film was used to screen out visible light, which would have blackened the film.

The picture shows that the principal source of x-rays reaching the earth is the low-density corona surrounding the mass of the sun. Immensely larger quantities of this radiation are produced within the sun proper. But most of these x-rays, except in the case of storms such as the one appearing near the center of the photo, are re-absorbed within the sun itself and not radiated into space.

The peculiar J-shaped marking and the small blotch at the top of the corona have been subjected to the scrutiny of scientists, who have decided that they are imperfections on the film.

The project was carried out under the direction of Herbert Friedman of the Naval Research Laboratory.

X-ray photograph of the sun, taken from a rocket fired 130 miles above the earth.

House Cuts Science Foundation Budget; Major Programs Endangered

On 20 April the House of Representatives approved a 1961 budget of $160 million for the National Science Foundation, reducing the Administration's proposal of $191,600,000 by $31,600,000 and cutting the foundation's original request of $214,835,000 by $54,385,000. Four major areas of support are seriously affected: basic research, reduced from the Administration's $78,800,000 to $70,283,000, a cut of $8,517,000; development of graduate research laboratories, reduced from $15 million to $2 million, a cut of $13 million; maintenance and operation of the National Radio Astronomy Observatory and the Kitt National Observatory, reduced from $5 million to $1,800,000, a cut of $3,200,000; and the dissemination of scientific information, reduced from $7,335,000 to $5,335,000, a cut of $2 million.

Some Effects

Despite growing recognition of the urgent need for more basic research, the House Appropriations Committee approved a budget that would eliminate the means of support for approximately 1000 advanced graduate students who would participate in such research. Even with the funds the President requested for basic research, the foundation would be able to support only 38 percent of the meritorious proposals that are received each year from more than 300 colleges.

Closely linked with the basic research program is the foundation's program to share with colleges and universities the very high cost of modernizing graduate research laboratories. At present, adequate laboratory facilities are not available in a majority of this country's institutions of higher education. The foundation launched a pilot matching-fund aid program last year, to which there was a vigorous response. The planned program will have to be radically curtailed if the present reduction from $15 million to $2 million is allowed to stand.

The appropriation that has been recommended for the two new national astronomical observatories, built at a cost of some $20 million, would provide only enough funds to continue the interim pre-operational support allowed in 1960. In 1961 major new instruments should be in full use, others should be tested, new programs should be launched and a new staff employed. One of the new programs that would have to be canceled would be that for the space telescope, which is expected to constitute one of the most significant advances in astronomy ever achieved.

Throughout the year much attention has been given, both nationally and internationally, to the ever-growing problem of dissemination of scientific information, of obvious fundamental importance. The development of more efficient electronic searching and retrieval techniques is essential if the research results are to be effectively utilized.

The National Science Foundation budget was included in the Independent Offices Appropriation bill (H.R. 11776), which received an over-all cut of approximately 3 percent. However, the foundation's appropriation was reduced by about 16.5 percent. The Senate will soon have an opportunity to modify the NSF budget reductions.

Promising Isotope with Short Half-Life Now Available

During the last 2 years the International Atomic Energy Agency has made special efforts to promote the production of calcium-47, which has a half-life of only 4.9 days, for use in medicine and radiology. Limited amounts of the isotope may now be obtained in England and the United States.

Because of the present method of production—the Ca^{46} (n, γ) Ca^{47} reaction—the isotope is unavoidably contaminated with calcium-45, which has the hazard-producing half-life of 164 days, prohibiting experiments on normal, healthy people. Work is now going on at Oak Ridge National Laboratory to increase the Ca^{46}/Ca^{44} ratio until the fraction of calcium-45 at pile-out time will be so low that it will not contribute to the radiation dosage.

Pure Samples Have Been Prepared

Laboratory samples of pure calcium-47 have been prepared both here and abroad—generally by means of fast neutrons or accelerated particles and a target, such as a separated titanium isotope. However, a spokesman for the Atomic Energy Commission explains that these samples are laboratory curiosities, for the methods used are far too expensive for routine production purposes.

Meanwhile, calcium-47 in its present form is considered satisfactory for diagnostic and research work in certain special patients and for agricultural and other applications. The International Atomic Energy Agency is now developing a research contract program to help researchers obtain the isotope and to coordinate further work on applications as well as work on the development of new production methods. Requests for calcium-47 should be sent to the United Kingdom Atomic Energy Authority's Radiochemical Centre, Amersham, Bucks, England, or to the Atomic Energy Commission's Oak Ridge National Laboratory, Oak Ridge, Tenn.

Grants, Fellowships, and Awards

Heart. Applications from research investigators for support of studies to be conducted during the fiscal year beginning 1 July 1961 are now being accepted by the American Heart Association. The deadline for applying for research fellowships and established investigatorships is *15 September*. Applications for grants-in-aid must be received by *1 November*.

Stipends in all categories have been increased this year, on the basis of the rising cost of living. Further information and application forms regarding research awards may be obtained from the Assistant Medical Director for Research, American Heart Association, 44 E. 23 St., New York 10, N.Y.

NATO institute travel. Under the sponsorship of the North Atlantic Treaty Organization, a number of Advanced Study Institutes will be held in NATO countries during the summer of 1960. These institutes, covering advanced specialized fields, vary in length from 2 weeks to about 2 months. The National Science Foundation has announced that a limited number of travel grants, including only transportation costs, will be available to U.S. citizens who have been accepted by the institute directors.

The 1960 summer program of Advanced Study Institutes will include the following.

"Elementary particles," Les Houches, France (director, Professor Cecile DeWitt, Department of Physics, Univer-

sity of North Carolina, Chapel Hill).

"Physics of microwaves," "Biophysics," and "Nuclear processes at low energies," all in Varenna, Italy (director, Professor G. Polvani, Societa Italiana di Fisica, Via Saldini 50, Milano, Italy).

"Thermal vibration in solids: specific heat and x-ray," Corfu, Greece (director, Professor Kessar Alexopoulos, Solonos Str. 104, Athens, Greece).

"Structure and evolution of the galactic system," Breukelen, Netherlands (director, Professor J. N. Oort, University of Leiden, Leiden, the Netherlands).

"Constituents of proteins," Göttingen, Germany (director, Dr. H. Stegemann, Medizinische Forschungsanstalt, Die Max Planck Gesellschaft, Bunsen Strasse 10, Göttingen, Germany).

"Physics of plasma," Risø, Denmark (director, Professor T. Bjerge, Danish Atomic Energy Commission, Risø Research Establishment, Risø, Denmark).

"Modern methods of structure determination," Manchester, England (director, Professor H. S. Lipson, Department of Physics, College of Science and Technology, Manchester 1, England).

"High-energy physics," Edinburgh, Scotland (director, Professor M. Kemmer, Tait Institute of Mathematical Physics, 1, Roxburgh St., Edinburgh 8, Scotland).

"Recent advances in food science," Glasgow, Scotland (director, Professor J. Hawthorn, Department of Food Science, Royal College of Science and Technology, 1, Horslethill Rd., Glasgow, W.2, Scotland).

"Fuel elements for water-cooled power reactors," Kjeller, Norway (director, Dr. Gunnar Randers, Institutt for Atomenergi, P.O. Box 175, Lilleström, Norway).

"Physics of upper atmosphere," Corfu, Greece (director, Professor M. Anastassiadis, Department of Physics, University of Athens, Athens, Greece).

Scientists in the News

Guerdon D. Nichols, dean of the College of Arts and Sciences at the University of Arkansas, has received the third annual Alexander Meiklejohn Award for Academic Freedom of the American Association of University Professors for having publicly led opposition to the Arkansas requirement that teachers employed by the state disclose their organizational affiliations. An Arkansas statute, known as "Act 10," requires every teacher to file a sworn affidavit listing the organizations to which he has belonged or contributed for the past 5 years. Presumably aimed at members of the National Association for the Advancement of Colored People, Act 10 applies to membership in all types of organizations—political, religious, social, and professional.

Addressing members of Phi Beta Kappa at the University of Arkansas a year ago, Nichols denounced the act as discriminating against the teaching profession and as an invasion of individual privacy. "But perhaps the greatest objection to Act 10," he declared, "is the contribution it is making to the atmosphere of fear and insecurity, and the consequent threat to academic freedom and the proper functioning of a true university."

Objecting to the act on principle, a number of Arkansas faculty members have refused to sign the affidavit and consequently have been compelled to leave the university. Some have been aided in finding new posts by the AAUP, and others are receiving financial support from the association. Review of Act 10 by the United States Supreme Court is scheduled.

Among the new fellows of the Royal Society are the following from the United States and Canada:

R. H. Dalitz, professor of physics in the University of Chicago's Enrico Fermi Institute for Nuclear Studies, distinguished for his numerous contributions to nuclear theory and the physics of elementary particles.

M. J. S. Dewar, professor of chemistry at the University of Chicago, distinguished for his studies of chemical structure and for his contributions to the application of quantum theory to organic chemistry.

D. K. C. MacDonald, principal research officer, Division of Pure Physics, National Research Council of Canada, Ottawa, distinguished for his investigations on the thermal and electrical properties of metals, with particular reference to the study of electron interactions.

Francis Birch, Sturgis Hooper professor at Harvard University, has received the William Bowie Medal of the American Geophysical Union for his 30 years of distinguished contributions to geophysical research. He was honored for having shown particular competence in engineering, in physical science, and in geology, and for "having brought the full power of these disciplines to bear" on his studies of the properties of rocks under the extreme conditions of heat and pressure that exist within the mantle of the earth.

The gold-headed cane of the American Association of Pathologists and Bacteriologists has been presented to **Eugene L. Opie**, 87-year-old pathologist. Although officially retired in 1941, Opie works almost daily on liver cancer research at the Rockefeller Institute for Medical Research, New York.

Dael Wolfle, executive officer of the AAAS, will deliver the Bingham Lecture at Columbia University on 10 May; he will discuss "Diversity of Talent." Wolfle was selected by a special committee of the American Psychological Association, sponsor of the annual honorary lectureship, in recognition of his "unique contributions to the study of human capacities and abilities and the manpower problem."

John B. Youmans, technical director of research in the Office of the Army Surgeon General, will receive the Groedel Medal of the American College of Cardiology on 27 May. As recipient of the award, Youmans will address the college on the humanities in medicine.

John H. Lupinski has been appointed physical organic chemist at the General Electric Research Laboratory, Schenectady, N.Y.

Fifteen awards for outstanding contributions to chemistry and chemical engineering were presented on 9 April in Cleveland at a general assembly of the American Chemical Society's 137th national meeting.

Wallace R. Brode, scientific adviser to the Secretary of State, received the Priestley Medal for distinguished services to chemistry. Brode—on leave of absence from his post as associate director of the National Bureau of Standards—is an authority on the scientific requirements for national defense and the international exchange of scientific information.

The Garvan Medal, recognizing outstanding service to chemistry by a woman chemist, went to **Mary L. Caldwell**, professor emeritus of chemistry at Columbia University and an internationally

known specialist in the biochemistry of sugars and starches. In addition to her contributions to chemical research, she is widely known as a teacher and administrator.

Watson Davis, director of Science Service and an editor, writer, and broadcaster, received the James T. Grady Award for distinguished reporting of chemical progress.

Charles D. Coryell, professor of chemistry at the Massachusetts Institute of Technology who worked on the development of the atomic bomb, received the ACS Award for Nuclear Applications in Chemistry, sponsored by the Nuclear-Chicago Corporation.

James B. Watson of Harvard University won the ACS Award in Biological Chemistry, sponsored by Eli Lilly and Company.

Elias J. Corey, also of Harvard University, received the ACS Award in Pure Chemistry, sponsored by Alpha Chi Sigma.

E. L. Jack, of the University of California's department of dairy industry in Davis, won the ACS Award in the Chemistry of Milk, sponsored by the Borden Company Foundation, Inc., New York.

Arthur B. Pardee, of the University of California department of virology and biochemistry in Berkeley, received the Paul-Lewis Laboratories Award in Enzyme Chemistry, sponsored by Paul-Lewis Laboratories, Inc.

Carl Djerassi of Stanford University, internationally known for his research on hormones and plant chemicals, was presented with the Fritzsche Award, sponsored by Fritzsche Brothers, Inc., New York.

The ACS Award in Chemical Education, sponsored by the Scientific Apparatus Makers Association, was presented to **Arthur F. Scott**, professor of chemistry at Reed College.

Herbert C. Brown of Purdue University, an authority on the structure of molecules, received the ACS Award for Creative Work in Synthetic Organic Chemistry.

The Fisher Award in Analytical Chemistry, for distinguished contributions to the science of analytical chemistry, was presented to **Philip J. Elving** of the University of Michigan.

Neal R. Amundson of the University of Minnesota, an outstanding mathematical engineer, received the ACS Award in Industrial and Engineering Chemistry, sponsored by the Esso Research and Engineering Company.

The 1960 Kendall Company Award in Colloid Chemistry was presented to **John D. Ferry** of the University of Wisconsin.

Professor **Robert W. Taft, Jr.**, of Pennsylvania State University, received the ACS Award in Petroleum Chemistry, sponsored by the Precision Scientific Company.

J. G. L. Michel, senior principal scientific officer, Mathematics Division, National Physical Laboratory, Teddington, Middlesex, England, will be in the United States from 30 May to 29 June. He will attend the International Conference on Partial Differential Equations and Continuum Mechanics at the U.S. Army Mathematics Research Center, University of Wisconsin, Madison, 7–15 June. His itinerary includes: Washington (31 May–5 June); Urbana, Ill.; Dayton, Ohio; Pittsburgh; Philadelphia; Princeton, N.J.; New York; and Boston.

Felix Haurowitz, distinguished service professor of chemistry at Indiana University, has won the $25,000 Paul Ehrlich Award of the Paul Ehrlich Institute in Germany for his work in immunology. Half of the award goes to the winner and the rest to research to be designated by him.

Peter J. W. Debye, a Nobel chemist (1936) and a retired member of the Cornell University faculty, has been appointed senior research scientist in the Institute of Science and Technology of the University of Michigan, a position he will hold from April through December.

Recent Deaths

C. J. Bakker, Geneva-Meyrin, Switzerland; 56; director-general of the European Organization for Nuclear Research since 1955; a member of the organization's directorate since its founding in 1952, when he was named first director of the synchro-cyclotron group; former professor of physics and director of the Zeeman Laboratory of the University of Amsterdam and former director of the Institute of Nuclear Physics, Amsterdam; 23 Apr.

Joseph C. Bell, Louisville, Ky.; 67; former president of the Radiological Society of North America; 25 Apr.

George Calingaert, Geneva, N.Y.; 63; retired professor of chemistry at Hobart and William Smith colleges and an authority on organometallic compounds; was associated with the Ethyl Corporation for 24 years, 18 of them in Detroit as director of chemical research; 16 Apr.

Francis J. Curtis, St. Louis, Mo.; 65; former vice president for personnel of the Monsanto Chemical Company; recipient of the 1959 Founders Award of the American Institute of Chemical Engineers in recognition of outstanding contributions in the field of chemical engineering; past president of the Society of Chemical Industry and the American Institute of Chemical Engineers, and past vice president of the AAAS (1949); 21 Apr.

Alexander Dillingham, Orleans, Mass.; 77; a former professor of mathematics at the United States Naval Academy, where he was on the teaching staff from 1917 to 1948; 26 Apr.

Jules Freund, Washington, D.C.; 69; chief of the laboratory of immunology in the National Institute of Allergy and Infectious Diseases (Bethesda, Md.); winner of the 1959 Albert Lasker Award for achievement in medical research; former chief of the division of applied immunology of the Public Health Research Institute in New York, where he served 14 years; 22 Apr.

Lyman G. Schermerhorn, Highland Park, N.J.; 72; horticulturist and professor emeritus, Rutgers University; developed the Rutgers tomato in 1934 and the wilt-resistant variety of pepper, called the Rutgers World Beater, in 1942; 19 Apr.

Robert M. Strozier, Chicago, Ill.; 53; president of Florida State University; was among those under consideration for the post of chancellor of the University of Chicago, where he had served for some years as dean of students and professor of Romance languages; 20 Apr.

Max von Laue, Berlin, Germany; 80; German physicist who received the Nobel Prize in 1914 for his discovery of the diffraction of x-rays by crystals; resigned from the Kaiser Wilhelm Institute in 1943 as an expression of his opposition to the Hitler regime; after the war was appointed head of the Max Planck Institute for Physical Chemistry; former professor at Göttingen University; in 1957 was one of 18 prominent German physicists who publicly deplored the decision to equip the West German armed forces with nuclear weapons and refused to take part in weapon development; 23 Apr.

Book Reviews

A History of Polar Exploration. L. P. Kirwan. Norton, New York, 1960. x + 374 pp. Illus. + plates. $4.95.
Sverdrup's Arctic Adventures. T. C. Fairley. Longman, Green, New York, 1960. xii + 305 pp. Illus. + plates. $6.

In his general history of polar exploration, Kirwan refers to a period of Scandinavian ascendancy around the turn of the 20th century. Among the modern Vikings none outranked Otto Sverdrup, whom Kirwan calls "an outstanding leader and the greatest ice pilot of his day." In *Sverdrup's Arctic Adventures,* Fairley allows the explorer to tell, in his own words, of the great expedition to the Canadian arctic, by condensing Sverdrup's *New Land,* originally published in 1904. To explain the man and his accomplishment, Fairley has added biographical information, explanatory notes, and a brief assessment of Sverdrup's significance. He has done a public service in making available one of the great stories of polar adventure.

Fairley's book might be presented as a case history illustrating Kirwan's study of polar exploration. By a miracle of compression, Kirwan has presented the story of many hundreds of years of effort to open the polar regions in less than 400 pages. He has accomplished this by emphasizing the evolution of polar exploration in its social and historical context rather than by analyzing geographical achievement and the development of polar techniques. His approach led him into the interesting field of the motives and impulses—economic, strategic, political, and personal—that lead men to risk their lives in the arctic and antarctic. Consistent with his viewpoint, but perhaps disappointing to some readers, is his treatment of the period since 1920 in summary fashion because sufficient time has not elapsed to establish historical perspective.

Kirwan, director of the Royal Geographical Society, has a certain quiet English pride. Lacking any chauvinism, unafraid to criticize his countrymen, generous in recording the achievements of other nations, the author, nevertheless, manages to keep the activities and accomplishments of Britons in the center of the stage. The same national viewpoint pervades all mention of political relationships in Antarctica.

These remarks are intended less as criticism than as a warning to the non-British reader. In compressing a mass of material into a small compass, mistakes are inevitable; Kirwan has committed very few. The volume should be on the bookshelf of everyone who is interested in polar exploration, general reader and specialist alike.

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China. Its people and its society and culture. Chang-tu Hu *et al.* Hraf Press, New Haven, Conn., 1960 (distributed by Taplinger, New York). xiv + 611 pp. $10.

For those who are interested in general knowledge about China, and especially for those who teach college courses on Chinese society and culture, there has long been the need for a comprehensive volume which would give a systematic presentation of Chinese society and culture in terms of its traditional pattern and its present shape of development. Unfortunately, almost without exception, the extant books that represent comprehensive surveys of China were written in the pre-Communist period and, largely, contain pre-World War II data. Their main body of information is at least 20 years old, while China has been radically transformed in a decade of Communist rule. Some old works have undergone recent revisions, but revision to change a form that has been firmly cast has obvious limitations. There are indeed many recent books on present-day China, but they are devoted mostly to one or another aspect of that country, and give the reader only a partial picture without an over-all perspective. In the light of this situation, this volume constitutes a distinctive and welcome contribution.

The comprehensiveness of the volume's contents is seen in its extensive coverage: historical résumé, geography and population, ethnic groups, linguistic systems, social organization, such social institutions as religion, family, government, economy, health and welfare, education, science and technology, art and intellectual expression, and information on mass communication, values and patterns of living, and national attitudes. All these aspects, with the exception of certain segments of the government and economy, are treated with comparisons between the traditional order and its recent transformations under Communist rule. The success of such a comprehensive treatment of a complex society with a vast population and deep historical roots is due in no small measure to the authors' unique opportunity to utilize the extensive resources of the Human Relations Area Files and the documents from the Files' subcontract projects on China. The success is due also to the fruitful use of the interdisciplinary approach by the authors, each of whom is a specialist on some aspect of China's society and culture. The volume shows a high degree of technical competence in its treatment of such subjects as ethnic groups, linguistic systems, the family, foreign relations, and education, and especially in its presentation of different facets of the Communist economy, which fills almost one-fifth of the volume. Such a task would have been extremely difficult for any single author to accomplish.

The value of the work would have been enhanced if, in the treatment of such subjects as religion and social organization, more consideration had been given to existing contributions in these fields. But as it stands, the volume has no counterpart as a work combining comprehensiveness with up-to-date information on an interdisciplinary basis, and, as such, it meets a long-felt need in the field of area studies.

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Sechzig Jahre medizinische Radiologie. Probleme und Empirie. Hans R. Schinz. Thieme, Stuttgart, 1959 (order from Intercontinental Medical Book Corp., New York). 275 pp. Illus. $4.65.

This little booklet was received at Munich with great enthusiasm by the several thousand participants in the 9th International Congress on Radiology (1959). Written by invitation, the booklet presents the story of the first 60 years of clinical radiology in very fine essays, giving a short survey of the problems as well as some stimulating sketches of the early personalities working in the field. This parade of the great "pioneers of radiology" is impressive; it creates curiosity and anxiety about progress during the next 50 years, although the start made by the younger generation has been so favorable.

A. T. KREBS

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Handbook of Industrial Research Management. Carl Heyel, Ed. Reinhold, New York; Chapman and Hall, London, 1959. xvii + 513 pp. $12.

The *Handbook of Industrial Research Management* is a most timely publication; industrial research has grown in an explosive manner to the point that "it is now big business." Carl Heyel, editor of the volume and author of its first chapter, points out that the management of industrial research has proved to be the most difficult of the responsibilities entrusted to company executives. Because industrial research has grown on a concurrent basis in many industrial areas, there has not yet been adequate time for establishing accepted principles of management. In fact, misunderstanding of the entire field is caused not only by a lack of recognition of its problem but by a lack of commonly understood terminology.

The 35 contributors to the *Handbook* are some of our most experienced managers of industrial research and consultants on management. In spite of the large number of contributors and the difficulty of the field, Heyel has managed to organize a very worthwhile book. Under the circumstances, one would expect that various portions of the book would treat the subjects in a manner that is not entirely consistent. There is, however, recognition throughout the treatment that trying to force research into fixed patterns or attempting to schedule or to price research for the sake of establishing appearances of good management can be dangerous or impractical. In the first chapter, Heyel gives a comprehensive treatment of the entire group of problems facing industrial research. The remaining chapters are written by specialists from each area and cover comprehensively the entire field from basic research to product development, from keeping top management informed to meeting day-by-day schedules, and from budgeting to accounting. The book will serve company management and industrial research management in two ways: it provides ready reference material, and it is stimulating for purposes of self-examination.

The editor has carefully avoided semantic discussions, a trap that besets most writers on research management. Nevertheless, he has not escaped the problem. In the chapter on basic research, Mervin Kelly clearly creates the atmosphere appropriate to the chapter title; elsewhere the words research and development are understood to loosely indicate all technical work short of assisting in the day-to-day problems of manufacturing. In one section of the book, about the process industry, the term research covers the establishment of pilot plants and, in one instance, the design of a processing plant and its operation during debugging phases. The editor and contributors seem to avoid defining engineering; apparently the glamour of the words research and R&D is too important to neglect. To the extent that the reader is mature and can keep himself straight, these shortcomings do not detract from the book. On the other hand, references to tables and other statistical data, or justification of any degree of budgeting on the basis of information obtained from the book, are dangerous without a careful review of what the specific table, paragraph, or chapter means. The editor and the authors cannot be blamed for this; they have done a herculean job. It is unfortunate that industrial research directors themselves have not arrived at meaningful terminology so that words like industrial research, development, product engineering, process engineering, general engineering, and manufacturing engineering might be characterized by the exactness that professional scientific people normally give to words.

IVAN A. GETTING

Raytheon Company, Waltham, Massachusetts

Russian-English Geographical Encyclopedia. I. Telberg. Telberg Book Co., New York, 1960. x + 142 pp. $9.80.

This work, despite its title, is a gazetteer; it lists about 1300 Soviet place names, with brief descriptions. It is basically a translation of the entries pertaining to the Soviet Union given in the second edition of M. S. Bodnarskii's *Slovar' geograficheskikh nazvanii* [*Dictionary of Geographic Names* (Moscow, 1958)]. However, the text for a number of entries has been condensed. No attempt has been made to evaluate the data in the Soviet source or to present additional information.

The publication is mimeographed on legal-size paper. The place names are given in Russian characters and are arranged according to the Russian alphabet. Each name is followed by a brief description in English, including a transliteration of the place name. An English index to place names and a map of the Soviet Union are included.

The population figures are taken from the 1956 official Soviet estimates rather than from the results of the 1959 census. Heights of mountains and lengths of rivers are given in metric units.

In translating and condensing, some shifts in meaning have been made. Thus, in the Russian original under *Kiev* we find: "During the German occupation, was heavily damaged. Now restored and expanded." The translation reads: "Was destroyed in World War II. Rebuilt."

This book does not provide as full coverage of Soviet place names as the *Columbia-Lippincott Gazeteer of the World*, but it does give more recent population figures. The encyclopedia has some entries (particularly for rivers) that do not appear in *Webster's Geographical Dictionary*. It may have some value as a quick reference aid if the other dictionaries are not available.

BORIS I. GOROKHOFF

Slavic and Central European Division, Library of Congress

Plant Pathology. An advanced treatise. J. G. Horsfall and A. E. Dimond, Eds. vol. 1. *The Diseased Plant.* Academic Press, New York, 1959. xiv + 674 pp. Illus. $22.

The art and the science of plant pathology have come a long way since F. Lamson-Scribner's modest 138-page book, *Fungus Diseases of the Grape and Other Plants and Their Treatment*, appeared in 1890 as the first American book dealing with plant diseases. In the volume under review, the editors and their collaborators needed nearly 700 pages to present the available data on the subject of diseased plants, and this is only one of a proposed three-volume work on the general subject of plant pathology. Succeeding volumes in the series will bear the titles *The Pathogen* and *The Diseased Population.*

As stated by the editors, "The purpose of this comprehensive treatise is to present an integrated synthesis of the parts of plant pathology. It is designed for the creative worker not for the beginning student. Many books discuss the specific diseases of plants but this work does not. Rather it treats of the concept of disease, not of diseases."

Nineteen phytopathologists (including the editors), all of whom are recognized specialists along the lines of their several contributions, supplied the 15 chapters making up the first volume. Horsfall and Dimond introduce the subject of the diseased plant by covering such points as "What is plant pathology, what is disease, and the impact of plant disease on society." J. G. Ten Houten and G. W. Keitt present adequate accounts of the scope and contributions of plant pathology and of the history of the science. K. Starr Chester discusses the many points necessary to answer the question: "How sick is the plant?" Six chapters are devoted to the major manifestations of disease—namely, the disintegration of tissue, abnormal effect on growth and reproduction, starvation, water deficiency, and alteration of the respiratory pattern. The several authors have handled their subjects skillfully and adequately.

Other vital aspects of the behavior of diseased plants are covered in authoritative chapters on the histology of defense in plants, the physiology and biochemistry of defense, hypersensitivity, and predisposition. In a final chapter on therapy, F. L. Howard and J. G. Horsfall present a thought-provoking account of disease control; they pay special attention to topical and systemic chemotherapy, both still somewhat controversial aspects of the subject. Each chapter concludes with a comprehensive series of citations to the literature reviewed in the text so that ready reference can be made to any point on which further detail is desired. In a general work of this nature, dealing to a very considerable extent with abstract matters, a detailed subject index is necessary, and this volume has been provided with a 50-page index.

The editors and their collaborators have succeeded admirably in presenting a scholarly study of an important field of human activity. This three-volume series, international in its scope and preparation, presents a firm foundation on which to erect a superstructure of future research.

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Arizona Place Names. Will C. Barnes. Revised and enlarged by Byrd H. Granger. University of Arizona Press, Tucson, 1960. xix + 519 pp. Illus.

This volume provides a list of place names arranged alphabetically by counties. The entries vary in length from a page or more (for the history of a county) to a few lines (for Mule Shoe Bend and Parrissawampitts Spring), and provide the following information: location, elevation, pronunciation, description, references to volumes containing further information. A bibliography and an alphabetical index are provided. The pronunciation guide was worked out by C. F. Voegelin, head of the department of anthropology at Indiana University.

New Books

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Walford, A. J., Ed. *Guide to Reference Material.* Library Association, London, 1959 (order from Bowker, New York). 551 pp. $12. The *Guide* provides an annotated list (approximately 3000 entries) of the leading reference books and bibliographies. Emphasis is placed on current publications, particularly British.

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Allen, Donald S., and Richard J. Ordway. *Physical Science.* Van Nostrand, Princeton, N.J., 1960. 836 pp. $8.25.

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Reports

Identification of Insecticides and Acaricides by Comparative Bioassay

Abstract. Toxicants in purified form can be identified by applying a base dose, consisting of the amount causing 50-percent mortality in one organism, to other susceptible organisms. This yields a mortality pattern which "fingerprints" the compound. Toxicants related by chemical structure or biological activity tend to possess similar mortality patterns.

Suitably sensitive, accurate, and rapid methods for qualitative determination of pesticides are needed. Bioassay procedures have desirable features but, almost without exception, only for quantitative determination of known toxicants. This report *(1)* outlines a bioassay method that shows promise with highly purified toxicants.

It has been suggested that limited identification of chemically related pesticides could be made by observing their rate or type of action. Sun *(2)* suggested that organophosphorous compounds could be differentiated as a class from chlorinated hydrocarbons by their faster rate of action in houseflies. Davidow and Sabatino *(3)* distinguished chlordane and related cyclodienes from unrelated chlorinated hydrocarbons by the characteristic rates of response of goldfish. Laug *(4)* could differentiate the gamma isomer from other isomers of benzene hexachloride by comparing the relative toxicity to the housefly. Burchfield and Storrs *(5)* noted differences in the photomigration response of mosquito larvae affected by different toxicants. The methods developed thus far seem to be limited to separation within a known and restricted group of toxicants, or between groups of compounds widely different in chemical composition and biological activity.

It is well known that there are large differences in the susceptibility of organisms to pesticides. This is a substantial factor in the development of the great variety of insecticides and acaricides in current use. Busvine and Barnes *(6)* showed these differences experimentally but did not utilize them for qualitative determination of toxicants. The method reported here is based on such differences, in four quite unrelated (and presumably physiologically different) organisms.

The four test organisms were the wild strain of the pomace fly, *Drosophila melanogaster* Meig.; the rusty grain beetle, *Cryptolestes ferrugineus* Stephens; a stored-products mite, *Tyrophagus putrescentiae* Schrank; and the brine shrimp *Artemia salina* Leach. *Drosophila* has been widely used by a number of investigators for quantitative determination of at least 13 pesticides. *Cryptolestes* has not been used previously for bioassays, though other beetles from stored grain (*Tribolium* spp.) have been. *Tyrophagus* has not been tested as a bioassay organism, but acaricides have been evaluated against it *(7)*. *Artemia* has been used as a test organism in the bioassay of nine toxicants *(8)*.

To insure uniformity, methods of obtaining and exposing the test organisms were standardized as far as possible. *Drosophila* adults were obtained within 24 hours of emergence *(9)*. *Cryptolestes* were removed from cultures at intervals such that adults 4 days old or less were obtained. These organisms were exposed, at 78°F in the dark, to a dry film of toxicant on the bottom of 1.25-oz. salve jars. Evaluations were made at 24 hours, with a further reading at 48 hours for *Cryptolestes*. The method of exposure for *Artemia* and *Tyrophagus* is given in detail elsewhere *(10)*, time of exposure for these organisms being 24 hours.

Dosage-mortality relationships were developed by the log-probit method outlined by Finney *(11)*. Thirty-one insecticides and specific acaricides in highly purified form were tested. These included the majority of pesticides in common use and also a few less well known ones because of their close chemical relationship to more common toxicants.

Log dosage-probit mortality regression lines can be used in a number of ways as a possible means of distinguishing toxicants. The angle of the slope of the line is typical for a given toxicant for any particular organism under standard conditions. It should also be possible to develop a typical toxicity ratio at the LD_{50} level, the amount required for this degree of effectiveness in various organisms being compared with the LD_{50} dosage for a base organism. Such methods were rejected because they require developing a regression line anew for each organism every time an unknown is tested, though these methods could be used in extremely difficult cases.

The method tested was that of establishing a base dose of an unknown toxicant in solution for one organism at the LD_{50} level. This dose was then applied to the other three organisms so as to yield specific mortalities within calculable limits. Thus, by starting with a standard dose, a compound could be "fingerprinted" by its effect on other organisms. With this method any of the organisms that is suitably sensitive will serve to establish a base dose. If the compound is sufficiently specific in its toxicity for several organisms, it can be separated on the first application of the dose standardized at the 50-percent mortality level for one of the organisms. *Drosophila* appears to be the most useful of the organisms tested for establishing a base dose for most toxicants. Exceptions are the specific acaricides, which do not affect *Drosophila*.

Figure 1 illustrates the separation of

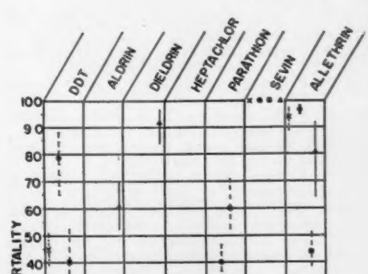

Fig. 1. Toxicity, for three organisms, of seven insecticides at the LD_{50} level for *Drosophila*.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

some representative pesticides (*12*) when the LD_{50} for *Drosophila* was used as the base dose. The vertical extension of each percentage of mortality represents the 95-percent confidence interval under our test conditions. It is obvious from this example that even closely related pesticides can be distinguished. For instance, with the *Drosophila* base dose, aldrin can be readily distinguished from dieldrin by its effect on the mite *Tyrophagus*. Allethrin can be confused with these two toxicants when tested on the basis of this single criterion, but clarification occurs in the effect of these toxicants on *Artemia* and *Cryptolestes*. Needless to say, there are instances where careful cross-checking of the effectiveness in all organisms is necessary to separate the 31 compounds tested; this can be done by selecting a different organism to establish a base dose.

Certain toxicants tend to separate out as groups; this indicates a chemical relationship or suggests similarity in mode of action. Chlordane and related cyclodiene derivatives form similar mortality patterns, as do several organophosphorus compounds. In like manner, all the specific acaricides affect only *Artemia* and *Tyrophagus*.

It will usually be necessary to remove waxes and other interfering substances from plant extracts before using this method. It is hoped that this procedure can be used for identification of an unknown toxicant, subject to confirmation by chemical procedures.

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18 December 1959

Temperature Fluctuations Accompanying Water Movement through Porous Media

Abstract. Temperature measurements were made at localized sites in bentonite, kaolinite, and small glass beads during infiltration. The temperature of the medium was observed to rise gradually and then to drop sharply as the infiltrating water approached and reached the measurement site. Temperature fluctuations were observed to be about 9°C for bentonite, 4°C for kaolinite, and 0.1°C for the glass beads.

The detection of water movement at localized sites in porous media, though frequently difficult, is usually possible. Determining whether the water arrives as a vapor or as a liquid is much more difficult, and often may be impossible. Velocity measurements which distinguish between liquid flow and vapor flow are even more complicated, but these measurements are precisely what is needed to investigate the kinetics of water movement in unsaturated porous media.

This is an old problem and one which received the early attention of soil physicists, although a satisfactory solution is still lacking. Apparently, Bouyoucos (*1*) was the first to place an air gap in the medium to distinguish liquid and vapor movement of water in soils. He arranged the apparatus containing the soil so that water vapor could diffuse unimpeded across a small air gap which completely interrupted liquid flow. This method was also used, with some modification, by Lebedeff (*2*) and by Taylor and Cavassa (*3*). By measuring the change in the distribution of a small amount of salt added to the medium, Gurr *et al.* (*4*) distinguished vapor flow from liquid water flow. More recently, Rollins *et al.* (*5*) used an external capillary on a closed soil-water system to measure vapor movement induced by temperature gradients. Measurements were taken at the steady state when the liquid flow through the capillary was presumed to equal the vapor flow through the unsaturated soils. In an excellent review of the whole problem of water and heat flow through unsaturated media, Philip and deVries (*6*) have discussed the experimental procedures and results of these investigations. They concluded that experimental methods have not satisfactorily distinguished between liquid and vapor transfer because of various complications inherent in each of the methods.

The measurement of temperature fluctuations due to the heat effects accompanying phase changes offers a means of differentiation and measurement of vapor and liquid flow. Let us visualize a liquid front advancing through a porous medium. Water molecules continually evaporate from the liquid and diffuse into the voids ahead, colliding with and being sorbed by the medium. Thus, one may predict that the advancing liquid front will be cooled, and that the medium ahead of the liquid front will be warmed. Hence, a temperature sensor located ahead of an advancing liquid front should show a gradual temperature rise due to sorption and condensation of water vapor followed by an abrupt temperature drop due to the arrival of the cooled liquid front.

To check the validity of this prediction, a series of experiments was performed. Ultrasmall thermistors and a potentiometer of high sensitivity made the experiments possible. Bentonite, kaolinite, and glass beads (*7*) were used as the porous media. Several small, cylindrical, Plexiglas sample holders were fabricated with provisions for embedding the thermistors in the medium during the preparation of an experiment and for controlling the introduction of water. Thermistor circuits which generated self-heating effects of less than 0.01°C were used in all the experiments. During the course of an experiment, voltage drops across the thermistors were continuously monitored by a two-pen Bristol recording

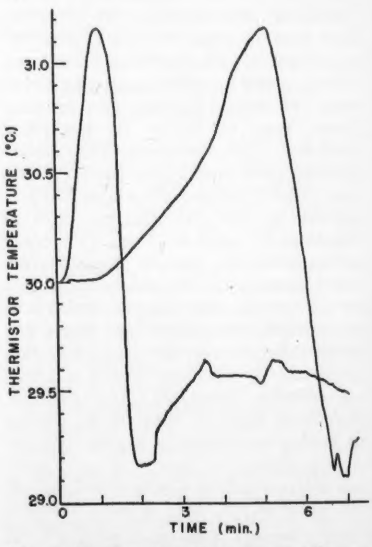

Fig. 1. Temperature–time curves taken at two sites in a kaolinite sample during infiltration by water. The curves were obtained by means of two thermistors embedded in the kaolinite sample. The temperature sensed by the thermistors is the ordinate and the time required for each thermistor to respond after the introduction of the water is the abcissa. The thermistor nearest the source of the infiltrating water gave the first response.

potentiometer. The experiments were done in an air bath at constant temperature; all materials were brought to constant temperature before each trial.

The result of an experiment with kaolinite, which is typical of all the experiments so far conducted, is shown in Fig. 1. The kaolinite was contained in a vertical, plastic cylinder (1.5 cm inside diameter and 6 cm long); it was supported in the cylinder by a porous glass wool plug. At the time the cylinder was filled, two thermistors were embedded in the kaolinite, one 5 mm and the other 10 mm from the sample top. The clay was gently packed into the sample holder and around the thermistors by means of a small mechanical vibrator held against the walls of the holder. So far, there has been no attempt to achieve truly uniform compaction in the several experiments. Deionized water under a 5 mm falling head was introduced at the top of the sample and allowed to percolate downward. The temperature of the water, sample, and sample holder was brought to 30°C at the beginning of the experiment in a thermostated chamber which was maintained constant ± 0.01°C throughout the experiment.

The temperature-time curves, shown in Fig. 1, substantiate the prediction made above, and can be interpreted in terms of the physical processes postulated. The erratic behavior of the thermistors after the abrupt temperature drop is due possibly to imperfect insulation of the thermistor leads.

Experience has shown that the magnitude of the temperature fluctuations can be correlated, at least qualitatively, with the kind of medium and its specific surface. The velocity of movement seems to be determined largely by the kind of porous medium and its degree of compaction. On wetting, some media shrink and some swell, causing either cracking or heaving which markedly affects the results. However, for the three porous media studied, every trial resulted in a curve having the same characteristics. Temperature fluctuations ranged from about 0.1°C for the glass beads and about 4°C for kaolinite to about 9°C for Arizona bentonite.

Since the color of all the porous media darkened on wetting, the visually observed arrival of the liquid front could be correlated directly with the abrupt drop in temperature. But, in order to verify this observation, a series of trials was made in which the infiltrating liquid was a solution of sodium chloride instead of deionized water. At various stages of the process, 2- or 3-mg samples of the medium were taken by a microspatula at different distances from the liquid source and analyzed for water content and for the presence of the chloride ion (*8*). It was shown conclusively that (i) the water content at the thermistor site increased during the initial temperature rise, (ii) the chloride ion was not present at the thermistor site until the temperature began to level off just before the sharp drop, and (iii) practically complete saturation of the medium at the thermistor site had occurred by the time the temperature began to drop sharply.

If chloride ion is transported only in the liquid phase, the evidence seems conclusive that the initial temperature rise is due to water vapor sorption. The arrival of chloride ion at the thermistor site when the temperature decrease first becomes apparent may be regarded as proof that the temperature drop is due to the arrival of the liquid front. The results of these experiments and careful visual inspection have indicated, however, that the liquid front does not have a clearly defined boundary. Apparently, films and fingerlike extensions race ahead of the nearly saturated zone.

Our principal conclusions are: (i) The movement of water through an unsaturated porous medium is not an isothermal process as is generally assumed. (ii) The movement of water—and likely other fluids—through unsaturated porous media can be studied to advantage by observing the heat effects accompanying the fluid phase changes. It appears that the theoretical treatment of infiltration and similar processes should consider the energy transfer implied by these experiments. The energy transfer ahead of the fluid by the diffusing vapor and heat flow due to temperature gradients appear to be important considerations (*9*).

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8. Water contents were determined gravimetrically. Chloride ion was detected by washing the small samples with deionized water and then adding silver nitrate to the acidified filtrate.
9. This report is Arizona Agricultural Experiment Station technical paper No. 561.

1 February 1960

Tympanic Muscles and Control of Auditory Input during Arousal

Abstract. A reticular stimulation producing a powerful arousal reaction decreases the potential in the cochlear nucleus evoked by a click. This reduction results from the contraction of the middle ear muscles, which lessens the pressure transmitted to the cochlea, and is not due to a direct neural inhibitory effect at the level of the first synapse of the auditory pathway.

Three years ago, Hernandez-Peon, Scherrer, and Jouvet published a note showing that the electrical responses evoked by clicks in the dorsal cochlear

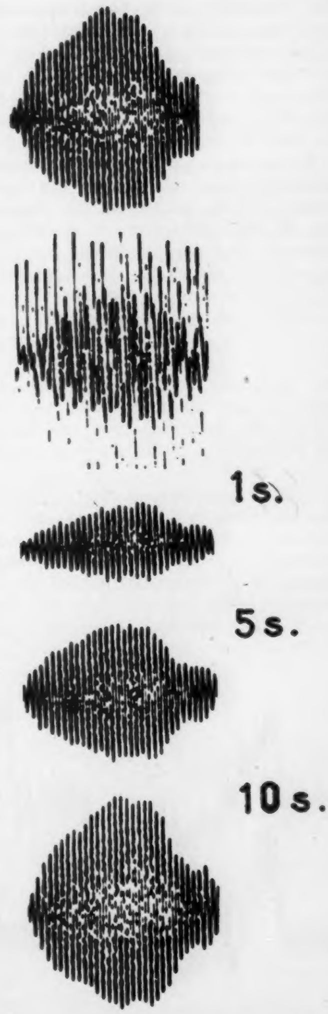

Fig. 1. Microphonic potential recorded on the round window in response to pips (0.25 kcy/sec) before, during, and 1, 5, and 10 seconds after a supramaximal mesencephalic reticular stimulation (150 pulses per second, 6 volts).

nucleus of the cat are depressed during attentive behavior (*1*). The authors attributed this effect to a reticular activating influence, based on the fact that they had observed a similar reduction of the dorsal cochlear nucleus potential in "encéphale isolé" cat, during reticular stimulation. It was therefore deduced that transmission in the first synapse of the acoustic pathway is inhibited by reticular discharges. This deduction provided the basis for an attractive theory, according to which reticular formation controls the first synapses of all sensory pathways (*2*).

However, our experiments have shown that injections of curare made in the "encéphale isolé" preparation suppress the reduction in amplitude of the dorsal cochlear potential induced by reticular stimulation. This suggests that tympanic muscles are responsible for the reduction of the response of the cochlear nucleus during arousal.

Reduction in amplitude of the microphonic potential recorded on the round window of the cochlea is the classical test of the contraction of middle ear muscles; since mesencephalic reticular stimulation induces this reduction (Fig. 1), it can be assumed that the reticular excitation controls sound transmission at the middle ear level by way of tympanic muscles. These muscles mechanically attenuate the pressure transmitted from the eardrum to the oval window through the ossicular chain and lessen the amplitude of acoustic stimuli reaching the cochlea.

After disinsertion of the tympanic muscles from the middle ear ossicles, reticular stimulation fails to induce any diminution of the cochlear response. Figure 2 shows potentials evoked simultaneously in the left and right cochlear nuclei. The responses recorded from the side which has intact middle ear muscles are reduced by reticular stimulation (lower beam) but are not modified on the side where stapedius and tensor tympani have been removed (upper beam). This implies that no inhibition of reticular origin takes place at the first relay of auditory pathways and that reduction in amplitude of cochlear nucleus potentials is a purely passive phenomenon.

From the point of view of motricity, the delay, evolution, and control of the contractions of tympanic muscles, under reticular stimulation, can be compared with the delay, evolution, and control of other motor facilitations induced by reticular activation. Furthermore, observation of the "encéphale isolé" cat's face during the reduction of the cochlear nucleus response by reticular excitation shows the pattern of muscular contraction such as has been described by Hess (*3*) as the facial component of the "tegmental motor reaction" of Thiele. Therefore the reticular control of auditory input may be understood to be the result of an infraliminal reflex facilitation, belonging to a generalized motor reaction (*4*).

Considered from the point of view of auditory sensation, contractions of tympanic muscles appear unimportant. Our experiments have shown that the diminution of microphonic potentials has never been greater than 13 db. Even in the case of reticular stimulation with powerful arousing action on the corticogram, the mean reduction registered was still under 5 db. This would explain that near-threshold responses only are reduced by reticular stimulation at the cochlear nucleus level. Therefore, in normal conditions of wakefulness, the reticular control of auditory input appears no more important than other aleatory modifications occurring through active behavior (masking effect, head orientation, and so forth) (*5*).

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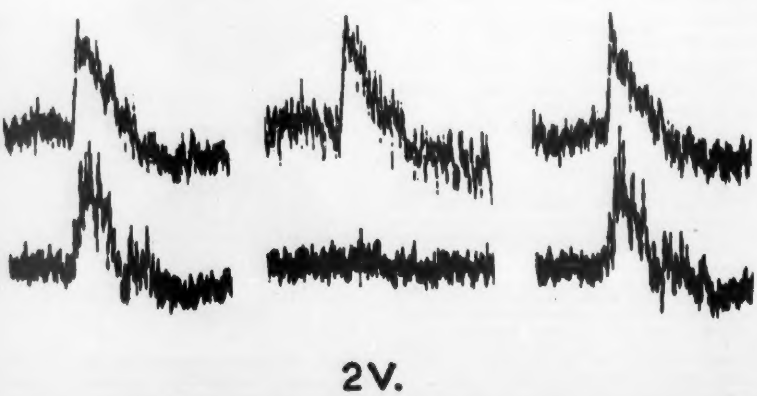

Fig. 2. Dorsal cochlear nucleus potential evoked by juxtaliminal clicks each second. Suppression of the attenuating reticular effect (2 volts, 300 cy/sec) on one side (upper beam) by cutting the tendons of tensor tympani and stapedius. Positivity upwards.

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30 October 1959

Technique for the Study of Alternate Metabolic Pathways; Epinephrine Metabolism in Man

Abstract. A general method of determining the relative magnitudes of different pathways of formation of a urinary metabolite from a single precursor substance is described. The method requires the administration of the precursor and an intermediate labeled with different isotopes, and the determination of the ratio of the isotopes in the metabolites. A preliminary application to epinephrine metabolism in man is presented.

The metabolic conversion of one compound to another, through more than one pathway, presents a special problem with regard to ascertaining the relative magnitude of each of the pathways. When an intermediate compound is also a major excretion product, it is possible to state which is the major pathway (*1*). This, however, introduces unnecessary variances, since more than one experiment is required, and it is not possible to appraise the extent to which each pathway is used or to determine the proportion of a final metabolite formed via a given pathway.

The present report shows that this information can be obtained in vivo, under different conditions or disease states, in a single experiment, by administering, simultaneously, compounds appropriately labeled with different isotopes and determining the ratios of the isotopes found in each of the excreted metabolites. When the total radioactivity in each metabolite can also be determined, the magnitude of each of the pathways may be expressed in terms of a percentage of the precursor substance. The development of a convenient method for the simultane-

ous determination of H^3 and C^{14} (2) has overcome many of the technical difficulties, and the principles of the method here described should find wide application in the study of alternate metabolic pathways. As an example of the type of problem encountered, and its solution by the double labeling technique, the metabolism of epinephrine has been studied, by using epinephrine-7-H^3 and metanephrine-methoxy-C^{14}.

Epinephrine can be metabolized by both monoamine oxidase (3) and O-methyltransferase (4). Figure 1 summarizes the known pathways of metabolism of epinephrine in man. The metabolites that have been shown to be present in urine (5) as well as probable intermediates, are indicated. The rate constants of the reactions are designated by K_{XY}, where the subscripts refer to the precursor X and the product Y. The fraction of a metabolite entering any given reaction can be shown to be equal to the rate constant of that reaction divided by the sum of the rate constants of all the reactions (or transfers) through which the substance leaves its metabolic pool. The fraction of epinephrine converted to metanephrine is

$$f_{EM} = \frac{K_{EM}}{K_{EM} + K_{EU} + K_{EC} + K_{ED} + K_{EO}}$$

and the fraction of metanephrine conjugated is

$$f_{MC} = \frac{K_{MC}}{K_{MC} + K_{MU} + K_{ML}}$$

The product of these fractions is the portion of an administered dose of epinephrine that would be excreted as conjugated metanephrine. If epinephrine-7-H^3 were administered, the amount of tritium excreted as conjugated metanephrine-7-H^3 would be $f_{EM} \cdot f_{MC} \cdot H^3_0$ (where H^3_0 is the total tritium in the epinephrine given). Similarly, the proportion of C^{14}_0, administered as metanephrine-methoxy-C^{14}, excreted as the conjugate would be $f_{MC} \cdot C^{14}_0$ (where C^{14}_0 is the administered dose). The H^3/C^{14} ratio in conjugated metanephrine after all radioactivity has been excreted would therefore be:

$$\left[\frac{H^3}{C^{14}}\right]_{\substack{\text{conjugated}\\ \text{metanephrine}}} = f_{EM} \cdot \frac{H^3_0}{C^{14}_0} \qquad (1)$$

Since H^3_0/C^{14}_0 is known, the fraction of epinephrine metabolized to metanephrine can be calculated.

The total H^3 and C^{14} present in 3-methoxy-4-hydroxymandelic acid (VMA) and 3-methoxy-4-hydroxyphenylglycol (MHPG) and their H^3/C^{14} ratios can also be expressed in terms of these fractions:

Table 1. Urinary excretion of radioactive compounds during the 48 hours following the intravenous administration of 38.4 μc of L-epinephrine-7-H^3 and 4.58 μc of L-metanephrine-methoxy-C^{14}. Results are expressed in microcuries.

Compound isolated	Subject G. J.			Subject D. W.		
	H^3	C^{14}	H^3/C^{14}	H^3	C^{14}	H^3/C^{14}
Metanephrine						
Free	2.63	0.568	4.62	2.08	0.395	5.28
Conjugated	9.34	1.64	5.68	7.34	1.31	5.62
3-Methoxy-4-hydroxymandelic acid	17.0	1.34	12.7	17.3	1.45	11.9
3-Methoxy-4-hydroxyphenylglycol	2.12	0.189	11.2	2.43	0.204	11.9
Epinephrine (free and conjugated)	1.23			1.26		

$$\left[\frac{H^3}{C^{14}}\right]_{VMA} = \frac{f_{EM}\, f_{ML}\, f_{LV} + f_{ED}\, f_{DA}\, f_{AV}}{f_{ML}\, f_{LV}} \cdot \frac{H^3_0}{C^{14}_0} \quad (2)$$

$$\left[\frac{H^3}{C^{14}}\right]_{MHPG} = \frac{f_{EM}\, f_{ML}\, f_{LG} + f_{ED}\, f_{DR}\, f_{RG}}{f_{ML}\, f_{LG}} \cdot \frac{H^3_0}{C^{14}_0} \quad (3)$$

The portions of these substances formed from epinephrine via the pathway through metanephrine are:

$$VMA = \frac{f_{EM}\, f_{ML}\, f_{LV}}{f_{EM}\, f_{ML}\, f_{LV} + f_{ED}\, f_{DA}\, f_{AV}} \quad (4)$$

$$MHPG = \frac{f_{EM}\, f_{ML}\, f_{LG}}{f_{EM}\, f_{ML}\, f_{LG} + f_{ED}\, f_{DR}\, f_{RG}} \quad (5)$$

The fractions in Eqs. 4 and 5 may be calculated by dividing the left-hand member of Eq. 1 by the left-hand member of Eq. 2 and the left-hand member of Eq. 3, respectively. If the total H^3 appearing in VMA and MHPG is also known, the quantity of H^3 forming VMA and MHPG via metanephrine can be determined and expressed as a percentage of the injected H^3 epinephrine (H^3_0). Thus the relative magnitude of each pathway in the formation of VMA and MHPG can be determined and the fraction of epinephrine converted to metanephrine estimated.

Because the metanephrine-methoxy-C^{14} is injected into the blood stream, excessive amounts are excreted into the urine in the free form. If the injected metanephrine behaved exactly as endogenously produced metanephrine, the H^3/C^{14} ratios of free and conjugated metanephrine would be identical. If the ratios are not the same, the excess free metanephrine-C^{14} would result in a lower H^3/C^{14} ratio in this compound. This amount of C^{14} never really entered the metabolic pool and must be subtracted from the administered C^{14} in determining H^3_0/C^{14}_0.

The excess C^{14} in free metanephrine

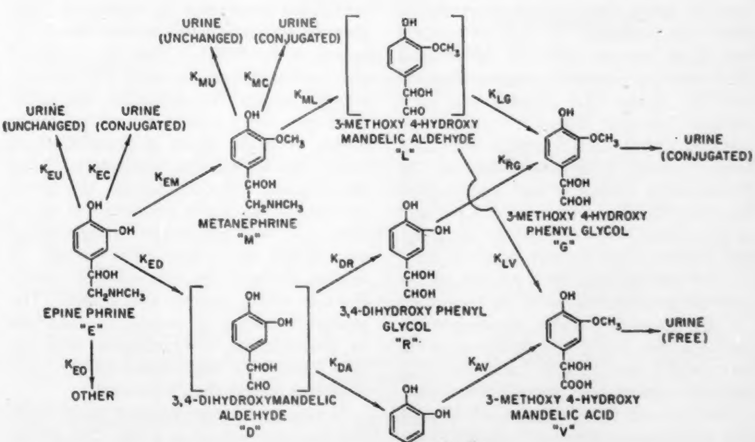

Fig. 1. Epinephrine metabolism in man. Compounds in parentheses have not been demonstrated. 3,4-Dihydroxyphenylglycol has been tentatively identified only in the urine of rats treated with pyrogallol.

can be estimated from the difference in ratios:

$$\left[C^{14}\right]_{\substack{\text{excess}\\ \text{in free}\\ \text{metanephrine}}} = \left(\left[\frac{C^{14}}{H^{3}}\right]_{\substack{\text{free}\\ \text{meta-}\\ \text{neph-}\\ \text{rine}}} - \left[\frac{C^{14}}{H^{3}}\right]_{\substack{\text{conju-}\\ \text{gated}\\ \text{meta-}\\ \text{neph-}\\ \text{rine}}}\right)\left[H^{3}\right]_{\text{free}}$$

The correction of the injected metanephrine $C^{14}{}_{0}$, by subtraction of the excess urinary free metanephrine-C^{14}, is necessitated by the initial rapid excretion of the injected compound. In order to be conjugated or metabolized, however, the injected metanephrine-C^{14} must enter the tissues. It is assumed that the lag in the initiation of these reactions is similar and that metanephrine and epinephrine can enter the various tissues with equal ease, so that a correction for conjugated metanephrine is unnecessary.

Using these principles, I made an attempt to evaluate the pathways of metabolism of epinephrine in man. Two normal males received 38.4 μc of L-epinephrine-7-H^3 and 4.58 μc of L-metanephrine-methoxy-C^{14} (*6*), and the various metabolites were isolated (*5*) from the urine collected during the following 48 hours. The amounts of H^3 and C^{14} in each compound were determined simultaneously in a liquid scintillation counter (*2*). Table 1 indicates the distribution of radioactivity in the various compounds isolated from the urine. From the ratios of H^3/C^{14} found for each compound in the equations outlined, it was calculated that 66.1 percent and 68.0 percent of the injected epinephrine was methylated to form metanephrine. Of this, 20 percent and 21.4 percent formed VMA and 2.25 percent and 3 percent formed MHPG. Since 44.4 percent and 45.2 percent of the injected epinephrine formed VMA, 24.4 percent and 23.8 percent must have been formed by deamination followed by methylation. Similarly, 2.25 percent and 3.3 percent of the MHPG was formed by deamination followed by methylation. A total of 95.8 percent and 98.1 percent of the injected epinephrine could be accounted for by methylation to metanephrine, deamination prior to methylation to form VMA and MHPG, and excretion as unchanged or conjugated epinephrine.

The use of simultaneous labeling of two different metabolites in determining the relative importance of alternate pathways of metabolism can be widely applied (*7*).

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6. A description of the preparation of these compounds is being written.
7. I would like to express my appreciation to Dr. Seymour S. Kety for his interest and encouragement, as well as his suggestions, in the development of this method.

18 December 1960

On the Thermal Boundary Layer of the Ocean

Abstract. Measurement of the long-wave infrared radiation from the top 0.1 mm of the evaporating ocean demonstrates the existence of a cool surface layer characterized by departures of as much as 0.6°C from the "surface temperature" found by conventional methods. Being very thin, the layer cools sufficiently rapidly to reestablish itself in less than 12 seconds after disruption by a breaking wave.

By means of simultaneous measurements of the radiation temperature and of the conventional thermometric temperature of the ocean, we have found evidence of a persistent cool boundary layer. The equipment used, shown in Fig. 1*A*, consisted of a double-beam radiometer having a spectral sensitivity in the band from 6 to 20 μ, a region in which the absorption in water is so high that 98 percent of the radiant flux originates in the first 0.1 mm. To minimize the necessary corrections for absorption by air and for reflection, the measurements were made at normal incidence at night from a position 2 m above the water. The water was shaded as required. For comparison, the temperature of the water beneath the radiation layer was measured by thermistors encapsuled in 1-mm glass beads, at depths dictated by the surface conditions of swell, waves, and ripples. The system had over-all sensitivity sufficient to discriminate temperatures with an uncertainty of less than 0.1°C, with response of less than 1 second.

Ocean measurements were made from the Scripps pier at a point 200 m off shore in water 7 m deep. A sample traced from the data is shown in Fig. 1*B*, which includes, for comparison, the "surface temperature" obtained by thermistor. The latter was checked by bucket sampling and mercury thermometer. The radiation temperature, when the ocean was shaded from the clear, cold night sky, was more than 0.7°C lower than the thermistor temperature. Since the screen used was at air temperature and therefore cooler than the ocean, a correction of +0.1°C must be applied to the measured value, which leaves a departure of the radiation temperature of more than −0.6°C. It should be noted that the conditions of wind and humidity were not conducive to vigorous evaporation. The effect of exposing the ocean to the night sky by removing the shade is readily seen in the right-hand section of the figure.

In order to evaluate the effect of breaking waves, a small electric rotary pump was submerged beneath the radiometer, positioned so as to draw water from a depth of 15 cm and direct it as a jet which welled up in the radiometer's field of view. It was determined by bathythermogram and thermistor that the water below the upper centimeter was isothermal within measurable limits. The result of intermittent pumping is shown in Fig. 1*C*. When the pump was run sufficiently vigorously to rupture the surface in the manner of a bubbling spring, the radiation temperature rose to approximately the values measured by the thermistor submerged at the level of the pump intake. When the pump was shut off, the radiation temperature dropped to its normal value in about 5 seconds, the cooling rate indicating that the effect takes place in a layer less than 1 mm thick. A remarkable finding was that less intense disturbance of the water failed to produce measurable effects.

Radiometric measurement over a breaking wave gave a concordant result. Coincident with the breaking, a momentary small warm signal was recorded, followed by a longer-lasting, stronger cold signal which seemed to coincide with the life span of the blanket of foam left behind by the wave. The whole disturbance lasted about 12 seconds; then the radiation returned to its normal value. Thus, on the open sea where whitecaps occur at a given point at relatively long intervals, the thermal boundary layer should be present, at least intermittently.

The chief features observed on the ocean were modeled in a controlled laboratory environment. In Fig 1*D* is shown, at the left, the radiation temperature of a salt-water surface being gradually warmed by radiation from the ceiling and walls of the room. Under these conditions, the heat flux was downward, and the water was initially in a state of stable stratification with a warm surface layer. As indicated in the figure, a fan was caused to blow periodically on the surface, the air stream having a velocity of about 1 m/sec and a relative

humidity of 55 percent. At the onset of evaporation, the radiation temperature quickly dropped about 1°C in 40 seconds, the polarity of its departure from the bulk temperature reversing from positive to negative. Cessation of the draft produced a return to the initial temperature but at a much slower rate, due, no doubt, to the diminished role of convection in the flow of heat. At the right side of the figure is shown the result of vigorous agitation by a conventional laboratory stirring device positioned so as to produce strong vertical currents in the water. The precipitous drop in temperature coincided with the arrival of cool subsurface water in the radiation layer. Increased evaporation caused by the fan while the stirring continued is plainly shown in the record, though the temperature departures are much reduced in amplitude, probably because of induced changes in the thermal conductivity of the boundary layer.

Additional laboratory experiments were performed with varying conditions of imposed radiation, evaporation, and stability. The general result was that the departure of the radiation temperature from the bulk temperature increased with the flux of heat through the radiation layer, the polarity being positive for downward flow and negative for upward flow. Thermal conditions were steadier in the case of downward heat flux. Moderate vertical stirring reduced but did not obliterate the thermal boundary layer.

It is well known that the ocean, in ice-free latitudes, is heated to a considerable depth by short-wave solar radiation, the heat balance being largely maintained by evaporation and long-wave back radiation from much shallower depths. It follows, therefore, that the heat flux in the superficial layers must, on the average, be upward. Consequently, one may conclude that the radiation temperature of the ocean and other natural bodies of water is usually lower than the ordinary surface temperature.

Because the thermohydrodynamics of a free saline liquid surface have not, as yet, been formulated in detail, it would be premature to attempt a theoretical analysis of the phenomena observed. Neither would it be prudent to identify the phenomena observed too closely with phenomena characteristic of rigid-boundary surfaces. Nevertheless, the experimental results appear consistent with the hypothesis that a boundary layer exists, immediately under the ocean surface, in which transfer of sensible heat is controlled chiefly by molecular conduction rather than by convection or turbulent exchange. In this layer, thermal gradients are maximized. The transition between the boundary layer and the deeper region where turbulent conduction is fully developed is characterized by unsteady thermal conditions which we observed by placing thermistors in vertical arrangement near the surface. Fluctuations appeared, having time constants of less than 1 second. The unsteadiness is much more fully developed when the heat flux is upward than when it is downward. Temperature fluctuations in air heated close

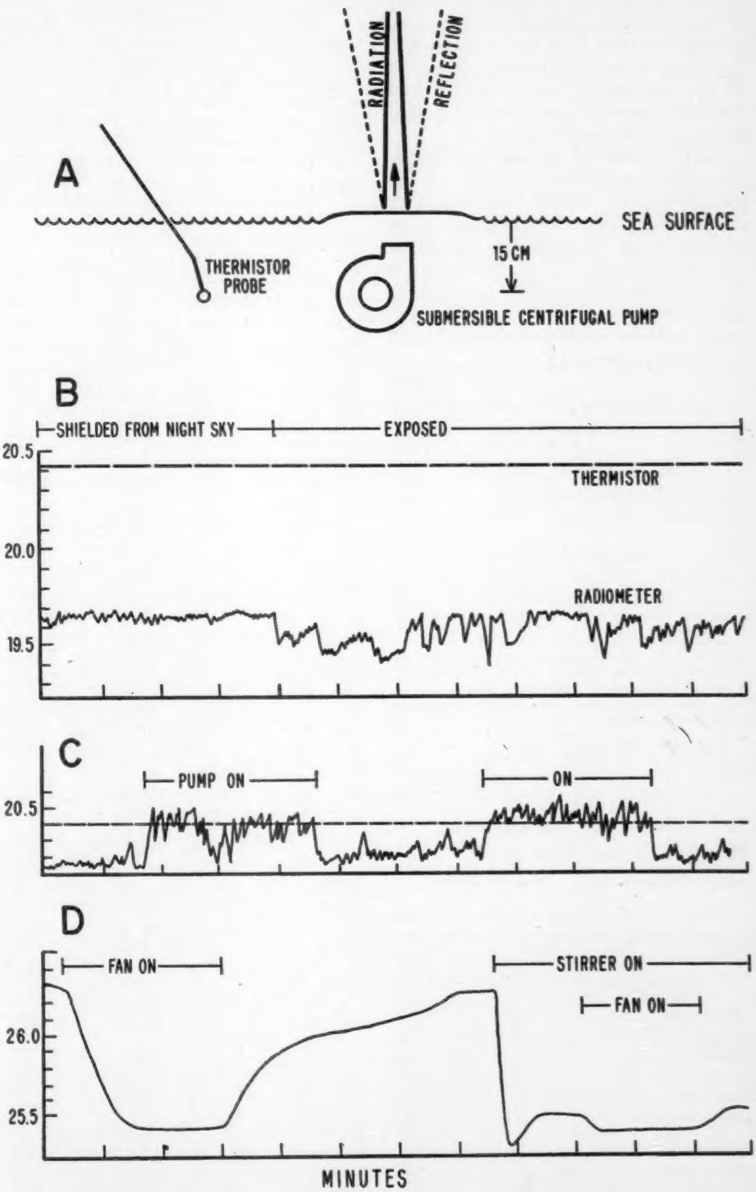

Fig. 1. Simultaneous measurements of the radiation temperature and of the subsurface temperature of evaporating water surfaces. (*A*) Schematic diagram of apparatus. (*B*) Trace of radiometer record in relation to thermistor temperature (dashed line), 2 October, 2300 (P.S.T.); wind, at 10 m above mean sea level, ½ m/sec; sky clear; air temperature 2 m above mean sea level, dry bulb 18.4°C, wet bulb 16.7°C; air temperature 8 m above mean sea level, dry bulb 18.0°C, wet bulb 16.2°C; relative humidity, 83.5 percent at 2 m, 85.0 percent at 8 m. (*C*) Effect of water jetted into surface by submerged pump. (*D*) Effect of induced evaporation and mechanical stirring on water in an insulated container. Air temperature, 32.8°C; fan velocity, 1 m/sec; relative humidity, 55 percent.

to the ground are described in some detail by Sutton (*1*) being attributed to bubbles of overheated air which periodically detach themselves from the thermal boundary layer. In a personal communication, R. W. Stewart, described similar phenomena observed by means of the schlieren method in the cool, unstable thermal boundary of evaporating water. Unsteady thermal conditions in the surface of cooling ponds and sheltered estuaries have been reported by Woodcock and Stommel (*2*).

Further study of the thermal boundary layer should reveal details of the mechanism by which contaminating surface films reduce evaporation from natural bodies of water. In general, it is to be noted that surface temperatures of the ocean or other wind-swept bodies of water determined by conventional methods are systematically biased in a positive sense (*3*).

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3. This study was supported by the Office of Naval Research. Credit is due Norman E. Head for technical assistance. This report is a contribution from the Scripps Institution of Oceanography.

21 December 1959

New Method for Manipulation, Maintenance, and Cloning of Single Mammalian Cells in vitro

Abstract. Individual mammalian cells can be isolated with the aid of easily handled glass beads to which the cells have become attached. Procedures for the preparation of cell cultures on beads, and for the recognition and manipulation of beads carrying single monocytes, HeLa cells, and Detroit-98 cells are described. Data obtained with *Brucella* infected monocytes, illustrating the efficiency of the method, are presented.

During studies of interactions between *Brucella abortus* strains of different virulence and mammalian monocytes maintained in vitro (*1*), it became apparent that certain problems—specifically, those associated with possible interference phenomena affecting continued ingestion of virulent brucellae—required an analysis of interactions involving single phagocytes. This requirement led to the development of a novel and relatively simple method for isolating single monocytes: exploratory trials indicate that this technique may also be used for isolating other mammalian cell types. The principal feature of the new method is the fixing and manipulation of single cells that have been permitted to adhere to the surface of small glass beads (*2*) partially embedded in a paraffin (or 2 percent agar) layer contained in small glass cups.

Table 1. Distribution of brucellae per monocyte among bead isolates and stained monocytes, determined by plating single monocytes and counting the resultant colonies or by the microscopic observation of stainable intracellular brucellae. Each figure in this tabulation indicates the number of monocytes containing, according to the column in which they are recorded, 0 to more than 10 bacteria.

No. of brucellae per monocyte												
0	1	2	3	4	5	6	7	8	9	10	>10	Total
Plating bead isolates												
11	5	3	6	4	4	2	0	0	1	0	4	40
Stained coverslip No. 1												
12	7	5	4	3	3	2	0	1	0	0	3	40
Stained coverslip No. 2												
9	9	6	6	3	2	1	1	0	1	1	1	40
Stained coverslip No. 3												
10	7	7	5	6	2	0	0	1	0	0	2	40

Before exposure to cell suspensions, the beads are boiled in detergent, washed in distilled water, dried, and sterilized by dry heat. They are then placed in sterile glass cups (5 ml Beckman *p*H-meter cups, cut to a height of approximately 5 mm) containing a thin layer of molten Vaspar (equal volumes mixture of noncarbolated Vaseline and household paraffin). The Vaspar layer is prepared by adding to thoroughly dried, heated cups a small amount of hot (about 100°C) Vaspar, the cups being immediately inverted to remove excess Vaspar. To the liquid Vaspar layer remaining within the cups, beads (about 500 per cup) are added by gentle sprinkling, which results in an even distribution of well-separated beads anchored in the Vaspar layer to about half their depth. Slow cooling of the bead-seeded cups is important and is achieved by placing the cups in heated petri dishes.

To isolate single monocytes, cells are harvested by previously described methods (*3*), and 0.8 ml of an appropriate suspension (containing approximately 5×10^4 monocytes per milliliter in a mixture of autologous serum and Hanks' solution) is added to each cup. The cups are sealed with silicone-greased 1-inch square coverslips, to prevent loss of carbon dioxide and water, and incubated at 37°C. After approximately 2 hours, the cups are examined for the presence of beads with single monocytes on their surface. Such beads may be removed for immediate examination or may be permitted to remain in the cups for any desired period of time.

The recognition of single monocytes on individual beads requires careful microscopic examination using proper lighting. We routinely employed a dissecting microscope with 18× ocular and 6× objective, using a sheet of green blotting paper in place of the usual substage mirror. When properly illuminated, monocytes adhering to the exposed bead surface are visible as differently refracting, irregularly-shaped cells, whereas the air bubbles found in most beads are seen as highly refractive circles.

For removal of the beads from their Vaspar bed, capillary pipettes with a diameter slightly greater than that of the beads were used. Beads were picked up by punching out a single bead plus its Vaspar base, and were removed from the pipette by tapping or by positive pressure.

The efficiency of the method is illustrated by a comparison of the distribution of numbers of brucellae in individual monocytes as determined by the bead method and by direct microscopic examination of stained monocytes (Table 1). For the former procedure, monocytes, infected with brucellae 30 minutes earlier, were introduced into the cups in the presence of streptomycin to kill all extracellular bacteria. Two hours later beads carrying single monocytes were removed and lysed on the surface of nutrient agar with the aid of 2 percent saponin (*4*), and the number of intracellular bacteria was determined by counting the colonies that developed after 5 days. For the procedure employing direct examination, infected monocytes were allowed to adhere to flying-coverslips in the presence of streptomycin, and were stained 2 hours later by Machiavello's technique (*5*). The data in Table 1 indicate a close correlation between the results obtained by these two procedures.

The method of isolating single cells

with the aid of beads has also been applied successfully to manipulation and cloning of other mammalian cell types, namely HeLa carcinoma cells and Detroit-98 bone-marrow cells. Two methods have been employed: (i) beads carrying single cells were immediately transferred to suitable tissue-culture media, or (ii) beads carrying single cells were permitted to remain in the cups until clones of sufficient size had established themselves on each of these particular beads. The latter procedure made it possible to obtain progeny from known single cells in the presence of other cells, a condition that in exploratory trials has proved favorable for the initiation of clones. For the purpose of recording the location of beads initially carrying only single cells, a photographic recording procedure was employed: first the location of every bead in the cup was mapped by projection onto photosensitive paper; 24 hours after the cups had been inoculated with a trypsinized cell suspension, the positions of all beads carrying single cells were marked on this photographic record. It should be added that provisions for the carbon dioxide tension required during the manipulation and growth of these mammalian cells were made in a simple manner: cups were incubated, unsealed, at 37°C in a CO_2-incubator (or in a closed jar in which CO_2-rich conditions were produced by burning a candle to extinction), and were inspected in a CO_2-rich atmosphere that had been created by CO_2-exhaust from a funnel placed adjacent to the microscope stage.

This procedure should prove useful for the primary isolation, manipulation, and cloning of many different cell types, particularly if initial maintenance of selected cells in the presence of other cells is prerequisite to the successful establishment of a clone (*6*).

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19 January 1960

Cytochemical Adenosine Triphosphatase of Vorticellid Myonemes

Abstract. A highly specific adenosine triphosphatase has been found to be localized in the contractile apparatus of vorticellids. It is most prominent in the cilia as well as in the myonemes which course the latitudes and longitudes of the cell and spiral in the flat peristome. The stalk displays more activity in the spasmoneme sheath than in the spasmoneme itself. The spasmoneme canal appears negative. A delicate fiber coils around the outside of the stalk in a helix. All these structures may be seen in the living protozoan by phase-contrast microscopy.

A very rich literature supports the hypothesis, originally presented by A. Szent-Györgyi (*1*), that contractility is dependent upon some interaction of adenosine triphosphate (ATP) and actomyosin. An important aspect of this interaction is the adenosine triphosphatase which contractile protein possesses by virtue of its myosin content (*2*). Extracts made from vertebrate (*2*) and invertebrate muscle (*3*) have this enzymatic property. Of fundamental importance is the fact that similar extracts of cells (*4*) or their isolated motor apparatus, sperm tails, (*5*) also display this enzyme activity.

Recently, direct demonstration of adenosine triphosphatase in intimate association with motor organelle was made for the fibers within sperm flagella by a cytochemical method (*6*). It is the purpose of this report to describe the cytochemical locus of adenosine triphosphatase in myonemes, the motor organelle of vorticellids, and other protozoans.

Vorticella convallaria were used throughout. They were derived from a clone cultured for several years by a previously described method (*7*) with some modifications. A cerophyl extract was substituted for the lettuce in the egg-lettuce medium. It is prepared by boiling 1 mg in 1 ml of distilled water for 5 minutes and filtering while hot into flasks which are then plugged and refrigerated. Equal parts of the egg and cerophyl are mixed to provide the culture medium. Routinely, petri dish bottoms were lined with non-nutrient agar before they were filled with the culture medium. Vorticellids detach from such a surface after 3 to 4 days of incubation at 25°C, thereby making for convenient harvest by light centrifugation after filtering through a No. 25 plankton net. They were then washed three times in sterile culture medium or Chalkey's solution before use in subculturing or in cytochemical study.

For assay, 20-μl aliquots of cell suspensions were placed on lightly albuminized cover slips (No. 0, 22 mm) and frozen directly on a block of Dry Ice. They were then thawed and dried with the aid of a fan. When dry, the cover slips were immediately immersed in substrate medium contained in Columbia staining dishes which had been previously equilibrated at 37 ± 0.2°C for 1 hour.

The substrate medium was essentially that of Padyluka and Herman (*8*). It contained 5 mmole of ATP (*9*), 2.5 mmole of cysteine-HCl, 20 mmole of $CaCl_2$, and 25 mmole of Veronal. The *p*H was adjusted to 9.4 and the solution was filtered before equilibration. In some experiments, 5 mmole of ADP, 12 mmole of muscle adenylic acid, (AMP), beta-glycerophosphoric acid, glucose-1-phosphate (*10*), and fructose-1,6-diphosphate (*11*) replaced ATP as substrate.

All substrates were added as the dry powder, and demineralized water was used throughout. All experiments included parallel preparations incubated in control media which lacked substrate. In addition, vorticellids that had been steamed for 10 minutes before incubation were also tested.

After incubation for 15, 30, 60, 180, or 240 minutes, inorganic phosphorus was visualized as black CoS by 3-minute immersion of cover slips in control medium saturated with $(Ca)_3(PO_4)_2$ by the addition of 0.1*M* Na_2HPO_4. They were then placed in 2-percent $CoCl_2$ for 3 minutes, followed by three washes in distilled water. Both the $CoCl_2$ and distilled water were brought to above *p*H 8 by the addition of 25 mmole of Veronal, as recommended by Danielli (*12*). Following this, cover slips were dipped in 1-percent $(NH_4)_2S$ for 2 minutes, washed

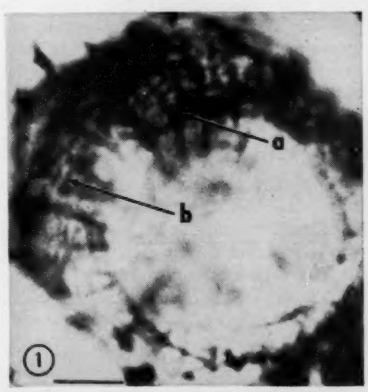

Fig. 1. Sites of adenosine triphosphatase in head. Incubation time, 60 minutes. *a*, Longitudinal myoneme; *b*, latitudinal myoneme. Magnification marker at lower left, 5μ.

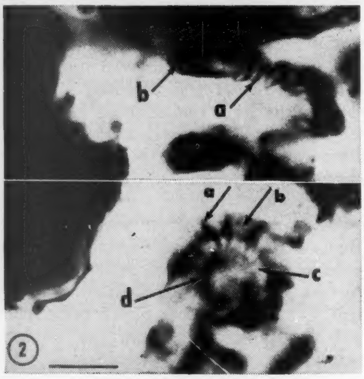

Fig. 2. Loci of adenosine triphosphatase in stalks. Incubation time, 15 minutes. (Top) Lateral view of upper coil of loosely wound stalk. (Bottom) Anterior view of coil of tightly wound stalk. *a*, Cortical helix; *b*, sheath of spasmoneme; *c*, spasmoneme canal; *d*, spasmoneme. Magnification marker at lower left, 5μ.

in three changes of tap water, and dehydrated in 80-percent ethyl alcohol for 1 minute, in 95-percent for 2 minutes, in 100-percent for 3 minutes, and were finally cleared rapidly in xylol and mounted in Clarite.

After 15 minutes' incubation with ATP as substrate, prominent fibers appear along the longitudes of contracted heads (Fig. 1). Some of these course in furrows along their entire length, while others seem to bend to join opposite fibers at the peristome, thereby forming characteristic arcades. The area between these fibers is dotted with numerous granules which presumably are mitochondria. In some cells, other, more delicate, fibers course around the latitudes. These become more prominent after 30 minutes, and together with the longitudinal fibers, give the pellicle an over-all basket-weave appearance. The peristomial shelf contains another fiber which follows a flat spiral beneath the adoral ciliary membranes. The cilia, which form the membranes, are also positive. A similar pellicular net of longitudinal, latitudinal, and spiral fibers were described by Entz (*13*), who used conventionally fixed and stained materials. They are the myonemes of the head and impart its characteristic motility.

Another fiber associated with an adenosine triphosphatase winds around the stalk as a helix in the outer membrane of the spasmoneme sheath (Fig. 2, *a*). It has the same order of activity as the myonemes in the head, as it becomes prominent after 15 minutes of incubation, and presumably is a structural embellishment of these. This cortical helix resembles one figured by Faure-Fremiet (*14*), and may be analagous to the helix in sperm tails (*15*). The sheath which surrounds the spasmoneme (Fig. 2, *b*) appears densely positive in many individuals after 15 minutes. The spasmoneme canal is always negative (Fig. 2, *c*), whereas the spasmoneme (Fig. 2, *d*) displays only moderate activity in the shorter incubation periods.

It should be mentioned that the spasmoneme usually appears darkened in occasional individual stalks of control preparations, therefore making it difficult to evaluate cytochemically. I believe this darkening to be the result of hydrolysis of tightly bound endogenous substrate because the spasmoneme of steamed vorticellids is lightened to its inherent refractility.

The adenosine triphosphatase associated with myonemes is highly specific since the latter appear most intensely when ATP is used as substrate. The enzyme does not attack AMP, beta-glycerophosphoric acid, glucose-1-phosphate, or fructose-1,6-diphosphate. Only slight visualization occurred with adenosine diphosphate.

All myonemes may be seen by phase-contrast microscopy of the living organism. Longitudinal and latitudinal myonemes and the granules between them appear in compressed heads. When the stalk is actively contracting or relaxing, striae appear along its entire length. I believe these to be identical with the cortical helix. Such demonstration confirms the reality of the structures found cytochemically.

The evidence presented indicates that the myoneme is intimately associated with a specific adenosine triphosphatase and thereby is provided with the equipment necessary to make up the free energy deficit incurred in the contractile process. It is suggested that the detailed morphology of myonemal systems as revealed cytochemically may serve to provide further biochemical basis to demonstrate and confirm taxonomic relationships (*16*).

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Penetration of Lead by the Wood Piddock Martesia striata

Abstract. An attack by *Martesia striata* Linnaeus on the lead sheathing of a power cable is described. This is the third such attack recorded and all have occurred in Florida waters. A guide for describing future attacks is recommended with the hope that the specific conditions under which attacks occur can be learned.

On 15 August 1959 an electrical power cable extending 1060 feet across Boca Ciega Bay beside the Treasure Island Causeway, St. Petersburg, Fla., shorted out. The cable had been placed in service during the spring of 1953 and had no previous history of malfunction. After the cable was raised it was found that the protective sheathing of a section about 4 feet long, approximately 200 feet from the west shore of the bay, had been damaged. The sheathing consisted of an outside layer of asphalt-impregnated jute over a closely coiled wrapping of heavy steel armor wire over a second layer of asphalt-impregnated jute which surrounded a tube of pure lead that had an outside diameter of about 55 mm and walls 3 mm thick. A three-conductor, paper-insulated cable lay inside the lead tube.

In the damaged section (at a depth of about 8 feet) the steel wires had rusted, snapped, and exposed the layers beneath. In some areas the jute had been eliminated, and the lead sheath beneath was exposed. There was no evidence of abrasion or oxidation on the lead surface. It was found, however, that the exposed lead was both pocked and riddled with small holes in each of which could be seen a small molluscan shell. It is not known whether the jute layer was penetrated before the lead, or whether any exposed areas of lead were not attacked.

The mollusks proved to be young pholadids, *Martesia striata* Linnaeus (*1*). The specimens appeared to be identical with *Martesia funisicola*

Bartsch and Rehder (*2*) (described from a specimen which had also bored into a lead-sheathed power cable). Turner (*3*) has synonymized *M. funisicola* with *M. striata* and has stated (*4*) that she considers the specimens from the lead sheaths to be abnormal; probably because they had been boring in such hard material.

The greatest diameter of any of the holes in the section of attacked lead sheathing available to us (125 mm long; 180 mm circumference) is about 6 mm, at a depth of about 2 mm in the lead. These findings are comparable to those of Snoke and Richards (*5*) for an attack they reported. Five of the ten borings in this section had completely penetrated the sheathing. All these attacks were concentrated in a 215° arc of the sheath, but supposedly there were other sections which were completely attacked.

The present report constitutes the second verified record of *Martesia striata* boring into lead. A third record (*5*) is probably attributable to this species. All three attacks have occurred in Florida waters: Boca Ciega Bay, St. Petersburg; Ortega River, Jacksonville (*5*); and Lake Worth, West Palm Beach (*2*). All three attacks were upon the lead sheathing of power cables, and, at least in the Boca Ciega Bay and Ortega River attacks, occurred in the same type of cable (after the outer steel wrapping had rusted through). The type of cable sheathing attacked is presumably in service in *Martesia* inhabited waters in other areas, and it is surprising that there are no other records of attacks on these cables. The conditions in Boca Ciega Bay are turbid ones, and there is considerable silting in the causeway area (Florida Power Corporation diver's report). The salinity is usually moderately high (estimated at 25 to 32 per mil, based on determinations made at various points in the bay) although during rainy seasons it may be much lower (1959 had the highest recorded rainfall on record for St. Petersburg, although the rainfall for August of that year, 9.54 inches, was close to the 45 year average, 9.16 inches). Lake Worth conditions probably approximate those in Boca Ciega Bay. The Ortega River attack probably occurred under turbid conditions and at a low degree of salinity (*7*).

In the event of future attacks, certain data should be recorded in order to facilitate the determination of the specific conditions under which attacks occur. The following information would be most useful: locality, general locality description, date, depth, salinity, turbidity, temperature, weather conditions, nature of bottom, position on bottom of attacked section, surface nature of lead (oxidized, clean, and so on), thickness of lead, position of individual penetrations, density of attack, and whether other substances were penetrated before the lead was reached.

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23 December 1959

Physiological Measurements on a Live Whale

Abstract. Temperature, respiration, and electrocardiographic measurements were made on a stranded 45-ft. finback whale. This proved to be a practical means of getting physiological information on the large cetaceans.

The stranding of a 45 foot finback whale (*Balaenopterus physalus*) on a Provincetown, Mass., beach provided a fortuitous opportunity to make multiple temperature, respiration, and electrocardiographic measurements. We know of no other such measurements on large, live cetaceans. The whale died after 36 hours.

The whale was entirely exposed at low tide. It breathed at a steady rate of about once every 20 seconds. The animal lay mostly on its left side and appeared to breathe primarily with its right lung: only the right blow hole opened. It was clear that only a partial inspiration was possible due to the overlying bulk of the animal. At high tide the whale was almost completely afloat. It was then pressed against the beach by a slow swimming motion of its tail. Its breathing while partially submerged was slower and more regular, with intervals ranging from 90 to 120 seconds. When we have observed the same species at sea, it generally breathed six to eight times at intervals of half a minute and then sounded for 5 to 8 minutes.

Samples of the expired air were taken with a syringe held 6 to 8 inches inside the blow hole during expiration. Gas analysis of three samples showed that they contained 1.42, 1.50, and 1.66 percent CO_2 and 19.22, 19.30, and 19.22 percent O_2, respectively (RQ of 0.8 to 0.9). The gas samples were taken near the end of expiration (which lasted about 2 seconds), so they would more nearly represent alveolar air. The apparently poor utilization of the inspired air coupled with the rapid, shallow breathing indicate pulmonary insufficiency and suggest that anoxia contributed to the whale's death.

Temperature distribution in the blubber was determined with a thermistor-tipped hypodermic needle. The skin temperature during low tide was uniformly cold (10° to 14°C), over all of the animal except the dorsal fin. This was warm to the touch and had a temperature of 23°C on the thin trailing edge. The sea temperature was 6°C, and the air varied between 6° and 10°C. The temperature in the blubber increased linearly with distance from the surface, reaching values of 27° to 31°C at the point of maximum penetration of the needle (15 cm).

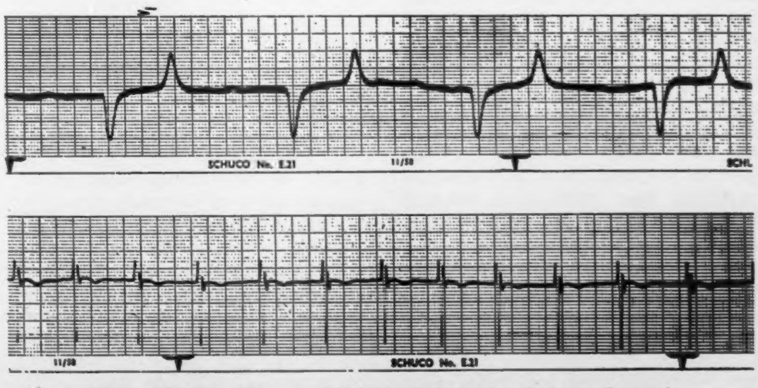

Fig. 1. Electrocardiogram of finback whale (top) and of man (bottom).

These slightly different gradients are probably due to variations in blubber thickness. We could not be certain that the thermistor probe penetrated completely through the blubber layer; therefore we do not know whether our maximum readings represent a true deep body temperature. A rectal temperature of 33°C was obtained with a flexible tube-mounted thermistor inserted 18 inches. Readings of 30° to 33°C were obtained under the tongue with the same instrument. From previous experience (*1*), we feel that the whale was 1° or 2° cooler than would be expected. The general mechanism of thermal regulation appears to be the same as that found in live porpoises which are approximately 1/100 as large as this whale (*2*). The blubber is an insulating layer, and the preferred pathway of heat disposal is through the uninsulated extremities.

Electrocardiograms were taken on an instrument which one of us (A.S.) uses in his private medical practice. Because the whale was completely out of the water we were able to place leads in most of the positions analogous to those used on humans. Figure 1 shows a precordial lead record from the whale heart as contrasted to a normal human record. The pulse rate was about 27 beats per minute, compared with 70 in man and more than 600 in the smallest mammals. However, it was still nearly twice that recorded on a much smaller white whale (*3*). Since the beats closely follow one another we presume that this represents tachycardia and that a more normal rate would be 8 to 10. The high rate probably reflected the deteriorating condition of the animal. The time scale for the events in a single beat are much longer than any known previously. The PR interval, for instance, was about 0.68 second as compared to half this in the white whale and a maximum of 0.20 second in humans.

This cursory report is given to show that it is possible to obtain physiological information from a beached cetacean if one has the instruments ready to take advantage of the situation. A live whale in the water is an imposing experimental subject, but grounded animals are more manageable and fairly frequent. Unfortunately most people consider the great mass of potentially putrifying meat more of a potential health hazard than a scientific opportunity. We would appreciate immediate notification of similar live strandings anywhere in New England.

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22 January 1960

Inhibition of δ-Aminolevulinic Acid Dehydrase by δ-Oximinolevulinic Acid

Abstract. δ-Oximinolevulinic acid competitively inhibits δ-aminolevulinic acid dehydrase at low concentrations.

The enzyme δ-aminolevulinic acid (ALA) dehydrase involved in the conversion of ALA to porphobilinogen has been studied by Gibson, Neuberger, and Scott (*1*) and others (*2*). In studying analogues of ALA it was found that δ-oximinolevulinic acid acted as a competitive inhibitor of ALA dehydrase, producing significant inhibition at low concentrations.

δ-Aminolevulinic acid and β-ketoadipic acid were purchased from the Nutritional Biochemicals Corporation. δ-Chlorolevulinic acid was synthesized by the method of Neuberger and Scott (*3*). δ-Oximinolevulinic acid was synthesized by the method of Neuberger, Scott, and Shuster (*4*). δ-Acetamidolevulinic acid was provided by Anthony Schrecker of the National Cancer Institute. 2-Amino-4-thiazolepropionic acid was prepared as described by Neuberger and Scott (*3*).

The homogenates were prepared from CAF_1 mouse livers as described by Gibson, Neuberger, and Scott (*1*). Each tube contained 1 ml of liver

Table 1. Inhibition of δ-aminolevulinic acid dehydrase by various compounds.

Concentration (*M*): Compound added	Concentration (*M*): ALA added	Volume of compound and ALA added (ml)	Ratio of compound to ALA	Inhibition (%)
		δ-Chlorolevulinic acid		
7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	100
7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	96
7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	0
7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	0
		δ-Acetamidolevulinic acid		
7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	37
7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	0
7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	0
7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	0
		β-Ketoadipic acid		
7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	100
7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	79
7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	11
7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	0
		2-Amino-4-thiazolepropionic acid		
7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	92
7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	8
7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	0
7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	0
		δ-Oximinolevulinic acid		
7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	100
7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	96
7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	75
7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	27
7.5×10^{-1}	5×10^{-2}	.33	10:1	95
7.5×10^{-2}	5×10^{-2}	.33	1:1	92
7.5×10^{-3}	5×10^{-2}	.33	0.1:1	72
7.5×10^{-4}	5×10^{-2}	.33	0.01:1	26

Table 2. Inhibition of δ-aminolevulinic acid dehydrase by δ-oximinolevulinic acid.

Tube	Concentration (*M*): δ-Oximinolevulinic acid added	Concentration (*M*): ALA added	Volume of compound and ALA added (ml)	Ratio of compound to ALA	Inhibition (%)
1	7.5×10^{-2}	7.5×10^{-3}	1.32	10:1	94
2	7.5×10^{-3}	7.5×10^{-3}	1.32	1:1	90
3	7.5×10^{-4}	7.5×10^{-3}	1.32	0.1:1	66
4	7.5×10^{-5}	7.5×10^{-3}	1.32	0.01:1	29
5	7.5×10^{-4}	9×10^{-2}	1.32	1:120	27
6	7.5×10^{-4}	6×10^{-2}	1.32	1:80	38
7	7.5×10^{-4}	3×10^{-2}	1.32	1:40	47
8	7.5×10^{-4}	7.5×10^{-3}	1.32	1:10	58

homogenate (1 part wet-weight CAF_1 liver homogenized in twice its weight of $0.15M$ KCl); 1 ml of $0.067M$ phosphate buffer at pH 6.8; 1 ml of $0.01M$ glutathione; and the volume of ALA and analog added as indicated in Tables 1 and 2. After evacuation of air, the mixture was activated at 37°C for 1 hour. In the experiments whose results are given in Table 1 and the lower half of Table 2 (tubes 5 to 8) the ALA was added 10 minutes after the analog. In the experiments in the upper half of Table 2 (tubes 1 to 4) the ALA and analog were added simultaneously. The incubation was continued for 1 hour and the amount of porphobilinogen was determined by use of Ehrlich's reagent after precipitation of protein as described by Gibson, Neuberger, and Scott (*1*). Pooled homogenates were used in the study of each compound. The percentage inhibition was calculated from the formula

$$100\ [1-(P_I/P_S)]$$

where P_I is the amount of porphobilinogen formed in 1 hour in the presence of inhibitor and substrate and P_S is the amount of porphobilinogen formed in 1 hour in the presence of substrate alone.

In Table 1 are presented the inhibitory effects of a group of compounds on ALA dehydrase. All the compounds produce inhibition of varying degrees at high concentrations, but only δ-oximinolevulinic acid is inhibitory at low concentrations. Two different concentrations of ALA (using 1.32 ml of $7.5 \times 10^{-3}M$ ALA and 0.33 ml of $5 \times 10^{-2}M$ ALA) were studied with the same ratios of δ-oximinolevulinic acid to ALA in both cases. The percentage inhibition is constant for a given ratio of inhibitor to analog at the different ALA concentrations. In these experiments the analog was added 10 minutes before ALA.

In the upper half of Table 2 (tubes 1 to 4) are presented the inhibitory effects of δ-oximinolevulinic acid when it is added simultaneously with ALA in the same concentrations and ratios as in Table 1. The inhibition is the same as it is when the analog is added 10 minutes before ALA. In the lower half of Table 2 (tubes 5 to 8) are the data obtained by using a constant concentration of δ-oximinolevulinic acid ($7.5 \times 10^{-4}M$) with varying concentrations of ALA added 10 minutes after the analog. It is seen from both tables that increasing concentrations of ALA overcome the inhibition of δ-oximinolevulinic acid, thus demonstrating the competitive nature of the inhibition. Also it is seen in both tables that at various concentrations of ALA and δ-oximinolevulinic acid the inhibition is relatively constant for a given ratio of analog to substrate.

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7 January 1960

A Genetic Constitution Frustrating the Sexual Drive in Drosophila paulistorum

Abstract. Hybrids obtained in the laboratory between two subspecies of *Drosophila paulistorum* possess a genetic constitution which is discordant enough so that the hybrid females repel the courtship of all males, and will mate with none. The hybrid males will court and will be rejected by almost all females, including their own hybrid siblings.

It has been shown (*1*) that the species *Drosophila paulistorum* actually represents a cluster of six subspecies, and that reproductive isolation of various sorts is being evolved between these incipient species, now in *statu nascendi*. Crosses between three (Centro-American, Amazonian, Andean-South Brazilian) of the six subspecies result in the production of fertile female and sterile male hybrids. The cause of the male sterility has been investigated (*2*) and found to depend upon the genotype of the mother involved. Any female which carries any mixture of the chromosomes of different subspecies deposits eggs giving rise to sterile male zygotes and to fertile female ones. (Intersubspecific insemination is accomplished more quickly here, and hybrid females can be tested for fertility by etherizing the females and immediately placing them with mature, unetherized males. The males will then approach and will often mount the females while they are still partly anesthetized. Subsequently, the females always produce offspring.) The male sterility is independent of the genotype of the male parents and the genotype of the sons themselves.

The mode of action of a reproductive isolating mechanism such as this seems to be unprecedented in genetic literature, but the same species-complex has evolved still another extraordinary isolating device: intersubspecific hybrids have been obtained by crossing Amazonian males with Andean-South Brazilian females. Most crosses between these two subspecies fail because of the powerful sexual isolation barrier. However, after repeated and lengthy attempts, viable male and female hybrids were obtained. It should be emphasized that these were normal males and normal females as far as the external and internal anatomy were concerned. Yet the genic endowments contributed by the parents of these hybrids are so discordant, that the hybrids are virtually unable to perform, successfully. the mating rituals that are normal in this species.

A study of the behavior of living flies under a microscope in special observation chambers showed that the hybrid females (25 have been observed and dissected so far) will not accept any males which court them, regardless of how vigorous or persistent the courtship is. They have been observed to reject consistently the males of both parental subspecies, as well as their own hybrid males. They accomplish this by assuming the posture of rejection of the courtship which is characteristic of *D. paulistorum*: the female lowers her head and elevates the tip of her abdomen so that the vaginal orifice is inaccessible to an approaching male. Only twice have Andean-South Brazilian males been seen to rush in so quickly that they succeeded in mounting the hybrid females; however, in one case, it took the female 2 minutes to repel the male by shaking violently from side to side, and, in the second instance, it took only 1 minute and 47 seconds. [Copulation normally takes an average of 17 minutes and 12 seconds in this species (*3*).] Furthermore, dissection of the female reproductive tracts involved, in physiological saline, showed that no sperm was transferred to the females in these two instances.

The hybrid males (19 have been observed and dissected so far) are of less interest in this respect, because they are completely sterile. Even so, they are rarely successful in courting females, and they have been placed and observed with mature females of both parental subspecies, as well as with their own hybrid females. These males have been observed in a total of only seven copulae, whereas a normal *D. paulistorum* male will begin courting again immediately after dismounting one female, and may inseminate several females per day.

It is here suggested that the disharmonies in the sexual behavior of the hybrid females may serve as a very efficient isolating mechanism between the incipient species. It is unfortunately not known whether the Amazonian and the Andean-South Brazilian subspecies occur anywhere sympatrically, but such sympatric occurrence has been recorded for other pairs of *D. paulistorum* subspecies (*1*). If such sympatric occurrence does exist, the possibility of hybridization cannot be excluded. However, the hybrid females, though potentially fertile, in the sense that their ovaries may be full of normal and mature eggs, would probably never mate. This would make the appearance of backcross progenies impossible.

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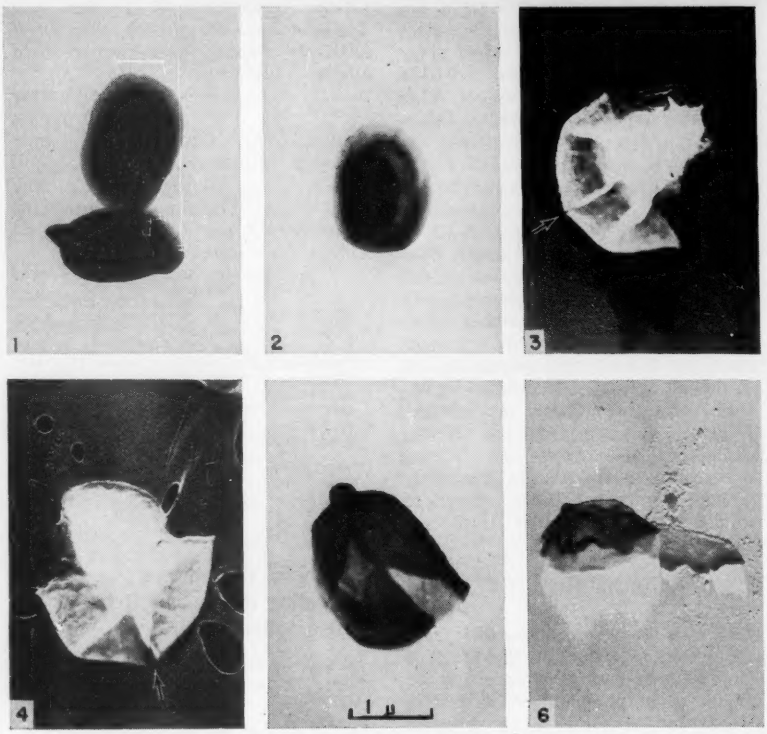
4. This investigation was supported by a postdoctoral fellowship, GF-9033, from the division of general medical sciences, U.S. Public Health Service.

23 December 1959



Figs. 1–6. Electron micrographs of *Bacillus megaterium*, taken with an R.C.A. electron microscope (EMU-2A) at an original magnification of 7400. Figures 3 and 4 are positive images; the others are negative. Fig. 1. Resting spores. Fig. 2. Spores incubated for 10 minutes—germination. Figs. 3 and 4. Spores incubated for 50 minutes—emergence of new cell and some elongation. The arrows indicate the split in the spore coat. Fig. 5. Empty spore case of an emerged cell, 60 minutes. Fig. 6. Empty spore case of a resting spore, obtained by grinding with glass beads. (× 12,500)

Spore Germination and Emergence of Bacillus megaterium

Abstract. *Bacillus megaterium* spores have a characteristic polar knob and equatorial ridge, or groove. During germination, the spore case appears to split along this ridge, and thus allows the new cell to emerge. Mechanically ground spores also split along this ridge, one part of the spore case being hinged to the other, the ridge being evident along a free edge. The equatorial ridge appears to be an area of susceptibility to mechanical pressures and, perhaps, in normal germination, to enzymic action as well.

We are primarily interested in the initial stages (*1*) of spore germination, when the spore loses its heat resistance, becomes stainable, and begins to consume oxygen. The study of later stages such as emergence may, however, help to illuminate early changes in spore germination. Electron micrographs of resting and germinating spores of *Bacillus megaterium* were prepared. The spores were germinated at 30°C in a medium buffered with $0.05M$ phosphate at pH 6.9 and containing 0.5 percent peptone, 0.02 percent yeast extract, and $0.025M$ glucose. Respiration in this medium has been described by Mandels *et al*. (*2*). The resting spores are opaque to electrons (Fig. 1). After 10 minutes in the germination medium, the spores become somewhat swollen, and dense material moves toward the periphery (Fig. 2). The spore case splits after 50 minutes of incubation, and a new cell protrudes from the case and begins to elongate (Figs. 3, 4).

The spore very often has what appears to be a polar knob and a ridge or groove circumscribing the major equator of the spore case. During the transition from spore to vegetative cell the spore case is often freed of the emerging cell (not adherent as in Figs. 3 and 4). The polar knob and equatorial ridge or groove are particularly pronounced in the discarded spore case shown in Fig. 5. We conceive of the equatorial ridge, or groove, as a line of weakness in the spore case more susceptible than the rest of the case both to physical and to enzymic attack. It is along this ridge, weakened perhaps by enzymic action (*3*) or by mechanical pressure of the swelling spore, that the case splits and allows the new cell to emerge. The cracks indicated by arrows in Figs. 3 and 4 support this idea. Furthermore, spores ground with glass beads show the same sort of split, one part of this physically damaged coat being hinged to the other with the ridgelike appearance evident along a free edge (Fig. 6) (*4*).

Note added in proof. Since we submitted this report, P. C. Fitz-James and I. E. Young have published electron micrographs which also show an equatorial ridge in the outer coat of *B. megaterium* spores (*5*).

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23 December 1959

Kodak reports on:

a substrate that doesn't split by itself . . . sooty things with a lot of physics in them . . . bringing sound movies down to size

Suggestion from East Berlin

May we have your attention, please, to a 411-word essay on lipase?

Ostensibly it advertises an Eastman Organic Chemical, *Phenyl Laurate* (Eastman 7885). To be sure, 25 grams of this compound may actually be purchased for $3 from the address given at the end of the essay. Because of difficulty in draping intellectual dignity around a bottle worth $3, it serves our purpose to issue the large, round declaration that enzymes are the most important subject on earth. Does not their interplay govern all activity in the biosphere, including that in the cerebra of men of business and science? Of course.

Permit us now to narrow the scope to one class of enzymes, the esterases. Lipases are esterases that split fats. Other esterases split simple esters of fatty acids. Lipases occur in certain animal organs and plant tissues. Although other esterases are fed into the mammalian blood stream from the liver, the lipase content of the blood serum is very low unless the duct of the pancreas is closed off.

To demonstrate and estimate an esterase, one gives it something (hereinafter designated a substrate) to split under fixed conditions, and one compares the amount of split product against a blank. Olive oil has been the standard substrate for lipase. The fatty acids released are titrated against sodium hydroxide. On page 221 of a certain book it says that this will work for lipase in blood serum. The measurement offers difficulties when the serum lipase level is normally low. It becomes a poor subject for wit when some foul derangement in the human machine raises the level to a point easy to measure.

The subway from East Berlin has brought out of Humboldt University there the suggestion (*Clin. Chim. Acta. 4*, 221) that phenyl laurate nicely liberates phenol in colorimetrically measurable quantity when acted upon by serum lipase. Soon after the news reached us, we prepared this compound for sale because it has good shelf life, where other proposed substrates all too soon split by themselves untouched by lipase. Then we took a different subway to Brooklyn, N. Y., to chat with a biochemist who told us of a considerable improvement in the phenyl laurate procedure.

Whoever will write name and address and the last three words of the preceding sentence on a postcard to Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company) will receive an abstract of the Brooklyn procedure as soon as it is published.

Adjustable boundary for the infrared

These sooty things have a lot of physics in them. The physics is of the old-fashioned type, not very clear, but not nearly so opaque as the little wonders themselves look when held to the light. Yet they transmit to 30μ in the very far infrared. Their utility lies in the easy adjustability of the spectral position of the transition from opacity to clarity. The opacity is achieved not by absorption and not by interference but by marvelously selective and effective scattering. What interference there is, in fact, operates on the side of clarity by beating down Fresnel reflection losses.

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Meetings

Virology

The Gustav Stern symposium on "Perspectives in Virology II" met in New York City on 25 and 26 January 1960 and provided opportunities for probing into many facets of virology. It was attended by 120 invited participants, who reflected the international scope of interest in this field and the diversity of the disciplines aimed at clarification of viral problems.

Basic aspects of virology were presented on the first day. T. M. Sonneborn (Bloomington, Ind.) discussed borderline host-parasite relationships as exemplified by the kappa agents of *Paramecium*. He described the exclusion of lethal kappa agents from the cell by the more efficient benign kappa competitive agents and proposed that similar studies should be undertaken with viral agents. Robley Williams (Berkeley, Calif.) defined the significance of ultramicroscopic particles in cells and the importance of relating them to viral agents through biological assay. He reviewed the electron-microscopic appearance of many of the animal viruses which have been viewed in purified form and in ultrathin sections. He was unable to detect a distinction in observable structure between cytolytic and oncogenic viruses. He outlined developments which would be needed for further interpretation of the cell-virus relationship.

G. Schramm (Tübingen, Germany) discussed mutation in viruses. He analyzed the kinetics of mutation of tobacco mosaic virus ribonucleic acid through treatment with HNO_2. W. Wilbur Ackermann (Ann Arbor, Mich.) discussed the biochemistry of vaccinial infection. He described how the mechanism of vaccinial infection conforms to the pattern of the small viruses. In HeLa cells, one particle can initiate a focus of infection, this is followed by an eclipse phase, then virus production occurs as an all-or-none phenomenon. The cytoplasm shows increased accumulation of protein, ribonucleic acid, and deoxyribonucleic acid prior to the appearance of new virus. James E. Darnell (Bethesda, Md.) demonstrated that a cell infected with poliovirus does not make virus-specific precursor molecules for the first 2½ to 3 hours after infection. The protein and ribonucleic acid components are then synthesized and joined as mature virus.

R. Walter Schlesinger (St. Louis, Mo.) discussed vagaries of adenovirus-cell complexes and showed, by example, that a single amino acid (arginine) in the nutrient fluid can influence the appearance of cytopathology, as well as the emergence of latent viral agents. A report by Harold S. Ginsberg (Cleveland, Ohio) on biochemical alterations in adenovirus-infected cells indicated that the intranuclear inclusion bodies were deoxyribonucleic acid; that this was newly synthesized as a result of viral infection; that it differed in structure from normal host deoxyribonucleic acid; and that it was probably a "single-stranded" deoxyribonucleic acid. The inclusions were the result of an overproduction of a viral precursor. The cellular protein increase contained three distinct biologically active fractions: (i) infectious viral particles, (ii) toxin, and (iii) common soluble CF antigen.

Selman Waksman (New Brunswick, N.J.) discussed experiences in the search for antiviral agents. He attributed failures to obtain antiviral agents from microbial cultures to searches which were concerned primarily with the properties of growth and metabolism in biological systems; however, viruses possess no intrinsic enzymatic mechanisms. Clarification of the mechanism of viral synthesis and viral activity within the cell may provide leads toward effective treatment.

Papers on the second day of the

symposium were concerned with applications. Alick Isaacs (London, England) defined "interferon" as a normal cell constituent produced in excess as a defense mechanism in response to virus stimulation. He characterized "interferon" as a protein with molecular weight of 100,000. It is nontoxic and nonantigenic at virustatic doses. He postulated that "interferon" may function as an antagonist to pentose metabolism of virus replication, thereby "starving the virus." Albert Sabin (Cincinnati, Ohio) showed that by the artificial selection of polioviruses with high reproductive capacity at low or high temperatures, the virologist has a tool by which he may be able to alter or detect the biological activity of many viruses. In discussing creative associations in biology, René J. Dubos (New York) pointed out how singular biological phenomena could be altered when one organism shared the environment of another.

Sidney Kibrick (Boston, Mass.) reviewed viral infections of the fetus and newborn. He pointed out that evidence on intrauterine and neonatal viral infections in man may be more significant than has been generally anticipated. He considered the perinatal period as a most hazardous period, when poliovirus, smallpox, vaccinia, salivary gland virus, and chickenpox could pose serious problems. He reviewed 53 cases of Coxsackie virus-induced myocarditis and interpreted the route of infection as transplacental. Françoise Haguenau (Villejuif, France) analyzed tumor virus-infected cells as viewed by electron-microscopy. She stated that ultrastructural lesions could not be considered specific, and that the presence of virus-like particles could be interpreted only as an abnormal sign. It was her opinion that infected and noninfected tissue culture preparations may provide the best media for electron-microscopy. Wallace P. Rowe (Bethesda, Md.) described an epidemiological study of mouse polyoma virus infection in wild mice in the Harlem district of New York City. This study provided thought provoking guidelines for similar studies on human tumors. While serological evidence of polyoma infection was highest in mice from congested areas, there was very low incidence of tumor disease. Polyoma virus was recovered from naturally infected wild mice and from cage contents (bedding). The virus appeared to be present in some commercial colonies. Robert J. Huebner (Bethesda, Md.) discussed viruses in search of cancer. His thought-provoking presentation provided the introduction to an informal seminar (of which H. B. Andervont, Bethesda, Md., was chairman) on criteria to establish viruses as a cause of human cancer. A panel of 14 tumor-virologists attempted to define guidelines for such a program. A résumé of their discussions is being prepared by Andervont.

Peyton Rous (New York) was honored during the evening banquet, on the occasion of his 80th birthday and of the 50th anniversary of his first publication on the Rous sarcoma virus. An eloquent tribute by Charles Oberling (Villejuif, France) brought into clear perspective the contributions of Peyton Rous to science and to society.

This symposium was a unique meeting. The formal presentation of papers induced lively discussions by the participants. The aim of the symposium was to provide a forum for exchange of information among individuals of diverse interests and a bridge across which such information could be conveyed to those who will apply it in public health. The proceedings of the symposium will be published as a *Festschrift* in honor of Peyton Rous, through the Institute of Microbiology, Rutgers University.

MORRIS POLLARD

Medical Branch,
University of Texas, Galveston

Forthcoming Events

June

1–3. Culture, Society and Health, conf., New York, N.Y. (Miss D. L. Keur, Hunter College, New York)

1–3. Instrumental Methods of Analysis, annual symp., Montreal, Quebec, Canada. (W. H. Kushnick, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh 22)

1–3. Radar Symp., 6th annual, Ann Arbor, Mich. (W. A. Blikken, Willow Run Laboratories, P.O. Box 2008, Ann Arbor)

1–4. American Assoc. of Bioanalysts and California Assoc. of Clinical Laboratories, annual, San Francisco, Calif. (Mrs. M. K. Higgins, 75 Buena Vista Ave., San Francisco 17, Calif.)

1–5. Irrigation and Drainage, 4th intern. cong., Madrid, Spain. (D. Diaz-Ambrona, Comité Nacional Espanol de la Comision International de Riegos y Drenajes, Ministerio De Obras Publicas, Agustin De. Bethencourt 4, Madrid)

2–4. Drugs Affecting Lipid Metabolism, intern. symp., Milan, Italy. (S. Garattini, c/o Institute of Pharmacology, Via del Sarto 21, Milan, Italy)

3–8. Pan American Medical Women's Alliance, 7th cong., San Juan, Puerto Rico. (Mrs. S. D. Rosekrans, 504 Newett St., Nullsville, Wis.)

5–8. Special Libraries Assoc., 51st annual, Cleveland, Ohio. (B. M. Woods, SLA, 31 E. 10 St., New York 3)

5–9. American Soc. of Mechanical Engineers, summer annual and aviation conf., Dallas, Tex. (L. S. Dennegar, ASME, 29 W. 39 St., New York 18)

5–9. World Power Conf., Madrid, Spain. (D. J. Pérez, Pozualo, Spanish National Committee, General Pardinas, 55, Madrid)

5–10. National Conf. on Social Welfare, annual, Atlantic City, N.J. (Natl. Conf. on Social Welfare, 22 West Gay St., Columbus 15, Ohio)

5–14. XXV Cold Spring Harbor Symp. on Quantitative Biology, Cold Spring Harbor, N.Y. (A. Chovnick, Biological Laboratory, Long Island Biological Assoc., Cold Spring Harbor)

6–8. Protein Structure and Function, 13th symp. in biology, Upton, N.Y. (D. E. Koshland, Jr., Dept. of Biology, Brookhaven National Laboratory, Upton, N.Y.)

6–10. International Conf. on Live Poliovirus Vaccines, Washington, D.C. (Secretariat, Pan American Health Organization/World Health Organization, 1501 New Hampshire Ave., NW, Washington 6, D.C.)

7–11. Microwave Tubes, intern. cong., Munich, Germany. (Nachrichtentechnische Gesellschaft im VDE (NTG), Frankfurt-am-Main, Osthafenplatz 6, Germany)

7–13. Dosimetry in Health Physics, symp., Vienna, Austria. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

7–15. Partial Differential Equations and Continuum Mechanics, intern. conf., Madison, Wis. (R. E. Langer, Mathematics Research Center, U.S. Army, Univ. of Wisconsin, Madison 6)

8–9. Selenium in Nutrition, conf., Ithaca, N.Y. (K. C. Beeson, U.S. Plant, Soil, and Nutrition Laboratory, Ithaca, N.Y.)

8–10. Canadian Federation of Biological Societies (Canadian Physiological Soc., Pharmacological Soc. of Canada, Canadian Assoc. of Anatomists, Canadian Biochemical Soc.), 3rd annual, Winnipeg, Manitoba. (E. H. Bensley, Montreal General Hospital, 1650 Cedar Ave., Montreal 25, P.Q.)

8–11. National Soc. of Professional Engineers, annual, Boston, Mass. (P. H. Robbins, NSPE, 2029 K St., NW, Washington 6)

8–12. American College of Chest Physicians, Miami Beach, Fla. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

9–10. American Geriatrics Soc., Miami Beach, Fla. (R. J. Kraemer, 2907 Post Rd., Warwick, R.I.)

9–10. Canadian Inst. of Food Technology, 3rd annual conf., Winnipeg, Manitoba. (W. J. Eva, Box 846, Winnipeg, Manitoba)

9–10. Society of Women Engineers, 10th annual conv., Seattle, Wash. (Mrs. J. A. Troxell, 3613 E. 43 St., Seattle 5)

9–11. Acoustical Soc. of America, Providence, R.I. (W. Waterfall, ASA, 335 E. 45 St., New York 17)

9–11. Endocrine Soc., Miami Beach, Fla. (H. H. Turner, 1200 N. Walker, Oklahoma City 3, Okla.)

9–11. National Speleological Soc., annual, Carlsbad, N.M. (G. W. Moore, U.S. Geological Survey, Menlo Park, Calif.)

9–12. American Medical Women's Assoc., Miami Beach, Fla. (Mrs. L. T. Majally, 1790 Broadway, New York 19)

9–12. American Rheumatism Assoc., annual, Hollywood-by-the-Sea, Fla. (F. E. Demartini, Presbyterian Hospital, 622 W. 168 St., New York 32)

9–12. American Therapeutic Soc., Miami Beach, Fla. (O. B. Hunter, Jr., 915 19 St., NW, Washington 6)

(See issue of 22 April for comprehensive list)

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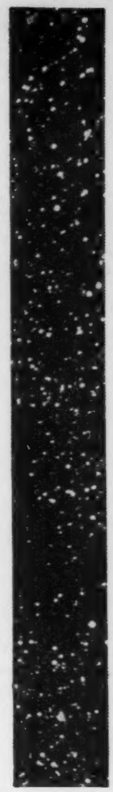

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Biochemist, 38. Teaching and/or research. Lipid, nucleic acids, isotopes in growth and viruses in cell cultures, animals. Teaching and broad methods experience. Publications. Box 106, SCIENCE. X

Botanist, Ph.D. Morphology-anatomy major desires college teaching position. Experienced. Box 105, SCIENCE. 5/20

Clinical Biochemist, Ph.D. Has organized and directed large units; expert in most "special" tests. Married, family, present salary over $11,000. Box 99, SCIENCE. X

Clinical Biochemist, Ph.D., trained at large general hospital; commercial laboratory experience; 3 years of teaching (biochemistry) and research at medical college. Desires hospital position permitting research. Box 104, SCIENCE. X

French-Speaking British M.D.; 10 years as clinician, 10 years in international health (WHO), postgraduate medical training France and experience French pharmaceutical industry, possessing French work-permit, offers services American company expanding European operations. Box 96, SCIENCE. X

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Biochemists. For pioneering study in the area of biochemical individuality, which is basic to all disease susceptibility. Holders of master's degree or doctorate will be considered if genuinely interested in this field. Generous stipends individually adjusted. Also part-time assistantships. Roger J. Williams, Director, Clayton Foundation Biochemical Institute, University of Texas, Austin. X

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Faculty of Agriculture. The University of Alberta invites applications for a position in the **Department of Animal Science as Assistant Professor,** starting salary $6000–$7000 depending on experience and qualifications, excellent prospects for advancement. Candidates should have a Ph.D. or equivalent in animal physiology with a minor in biochemistry and be qualified to conduct research involving the use of isotopes. Duties, to commence 1 September 1960, include fundamental and applied research with farm and laboratory animals, teaching and limited extension work.

Applications, accompanied by a recent photograph, and giving age, nationality, and other personal information, transcripts of academic record, list of publications and experience, and names and addresses of three references, should be addressed to the Head, Department of Animal Science, University of Alberta, Edmonton, Alberta. Closing date: **30 June 1960.** 5/6

Anatomy Department, Dalhousie University, Halifax, Nova Scotia. Applications are invited for two positions at the rank of **Assistant Professor** in the Department of Anatomy. Experience in the teaching of gross anatomy is essential and a willingness to undertake some teaching in neuroanatomy, histology, or embryology desirable. The successful candidates will be expected to participate in the active research program of the department, for which good facilities are available. Applicants with a medical degree will be preferred although those with an honors degree in medical science or biology will receive special consideration. The salary for a medical graduate with minimum qualifications will be $6500. The salary will depend upon qualifications and experience. Applications should be made to Professor R. L. deC. H. Saunders at the above address. 3/4; 4/1; 5/6; 6/3

Histologist, Histochemist, Ph.D. or equivalent. Research institute, New York. Modern, well equipped and staffed, air-conditioned laboratory. Opportunity for training in electron microscopy. Box 107, SCIENCE. 5/13, 20

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(a) **Biochemist,** Ph.D., to supervise medical school research, diagnostic cardiology laboratory; supervise technologists, train new employees, devise new techniques for chemical analysis; must be experienced in latest procedures, equipment; midwestern university medical center; to $9000. (b) **Bacteriologist.** Prefer also qualified immunology to work principally in joint research project in university school of dentistry, affiliated teaching hospital; some teaching, laboratory work required; Midwest. (c) **Virologist** M.S., Ph.D., for research, teaching, possibly diagnostic work and (d) **Microbiologist-Immunologist** Ph.D. to participate teaching microbiology to sophomore medical students, some research; eastern university medical school. (e) **Biochemist,** B.S., M.S., to head laboratory section, 300-bed voluntary general hospital; to $8000; midwestern college city 75,000. (f) **Pharmacologist,** Ph.D. trained, experienced cardiovascular field to supervise acute, chronic screening programs, study potential cardiovascular compounds; eastern company; about $10,000. (Please write for an analysis form. Our 64th year: Founders of the counselling service to the medical profession. Serving medicine with distinction over half a century.) Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

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Kalamazoo, Mich.

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Midwestern pharmaceutical firm seeks qualified man to head its Pharmacology Department. Age 35–45. Prefer M.D. and Ph.D. degrees. Should have 5 to 7 years of teaching experience as Assistant or Associate Professor and/or research experience with pharmaceutical firm. Broad knowledge of field is necessary. Duties consist of supervising other Ph.D.'s, supervision of pharmacology screening and broad decisions on various programs. Salary commensurate with experience.

All replies confidential. Send résumé of education and experience to

Box 101, SCIENCE

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Botanist. Experienced in microtechnique and general botanical preparation. For work with well-known biological supply house. Preparation of slides and other demonstrations for botany and general biology. Male or female, prefer Ph.D.; M.S. and experience acceptable. Good salary, benefits, paid vacation, and sick leave. Opportunity for advancement. Reply to Box 95, SCIENCE. 5/6

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Midwestern pharmaceutical firm seeks recent Ph.D. or M.D. graduate. Will specialize in pharmacology studies. Salary open. All replies confidential. Send résumé to

Box 102, SCIENCE

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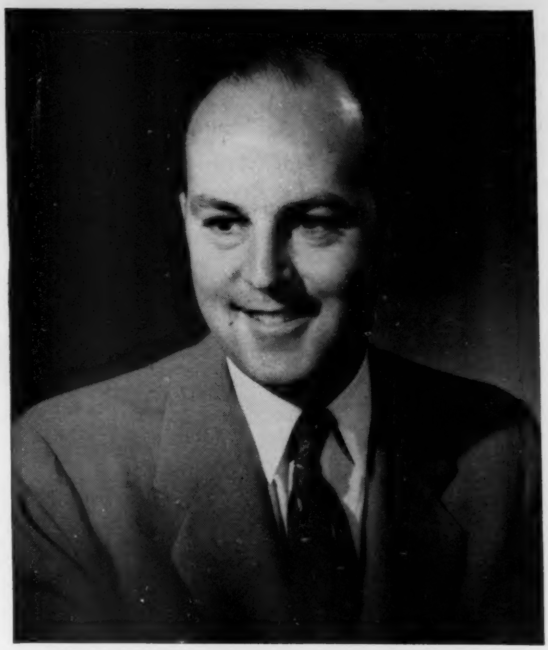

by Charles A. Kerner

Chief Engineer, Systems Support, Nortronics Division of Northrop Corporation

Some of today's most vital and challenging engineering research and development work is in the area of weapon systems support. Our defense planning calls for vastly more sophisticated weapons — weapons such as the Navy's Polaris missile, the Air Force's Sky Bolt air-launched ballistic missile, and the Army's new family of high-performance tactical weapons. Creating support systems for such weapons places new emphasis on specialized engineering talent.

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